INVESTIGATION INTO THE ACADEMIC PERFORMANCE OF STUDENTS IN BIOSCIENCE AT THE UNIVERSITY OF NATAL, PIETERMARITZBURG, WITH PARTICULAR REFERENCE TO THE SCIENCE FOUNDATION PROGRAMME STUDENTS

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Preface

The research described in this dissertation was carried out in the School of Education, Training and Development, University of Natal, Pietermaritzburg, from January 2001 to December 2001, under the supervision of Ruth Searle.

This study is the original work of the author and has not been submitted in any form for any diploma or degree to another university. Where use has been made of the work of others, it is duly acknowledged in the text. Chapters are written in the format of the International Journal of Science Education.

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Abstract

Performance of individual students in a course at a tertiary institution is usually reflected in a final mark that determines their progress and transfer to higher courses. Performance of students in a first year course, Bioscience at the University of Natal, Pietermaritzburg (UNP) was examined to determine if there were any patterns emerging in differential performance between students, particularly the performance of subgroups within the class. Of particular interest were English second language (ESL) students, and previous Science Foundation Programme (SFP) students. The latter are mainly previously disadvantaged Black students. Performance of students was compared in Bioscience 110 for the years 1995-2000 using Repeated Measures ANOVA. All subgroups of students showed similar trends in performance in Bioscience assessment tasks and final marks. However, the SFP students' final marks were lower than the other subgroups, and showed a decreased performance for the same period. Most students, excluding SFP students, fell in the 50-59% category for the final Bioscience 110 marks obtained for the period 1995-2000. There was no correlation between students' SFP final mark and their final mark in Bioscience 110.

The final Bioscience 110 mark is a combination of a class mark, practical examination and a theory examination and performance in these was investigated and compared to determine any patterns. Students performed best in class marks. All students performed poorly in the theory examinations. Theory examinations were investigated further, and were analysed in their component parts, namely multiple choice (MCQ), short questions and essay. Students performed best and consistently in MCQ. In contrast, students performed poorly in the short question and essay sections. Although the different ethnic subgroupings showed similar trends in performance, the SFP students showed the poorest performance. In particular, they scored lowest in the theory examinations where they performed more poorly than the other subgroupings in short questions

and essays that require higher order cognitive skills.

As SFP students are the main source of Black students who enrol for Bioscience at UNP, the performance of these students in their SFP Biology was assessed across years (1995-2000). Assessment marks were analysed to determine if they showed trends in the mastery of the skills and knowledge tested.

Given the trends found by the study, there needs to be ongoing curriculum development in both courses examined. In particular, the types of teaching and the assessment used to award a final grade need to be examined. For example, the contribution of essay writing, how it is taught and assessed needs to be monitored. The quality of test questions and writing assignments needs to be examined as part of course design and development. In addition, development of higher order thinking skills and the levels of these need to be examined at both SFP Biology and Bioscience levels.

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FOREWORD

I have always felt that the more one studies, the more one realises how little one actually knows. As someone that has come through a Science training, my framework and training has been mainly quantitative and within the boundaries of scientific method. Now as a lecturer to tertiary students, I realise that this alone is insufficient to be a good educator. I have realised the need for understanding the various educational theories related to learning and the skills and curricula issues that require attention to teach large classes or disadvantaged students. Furthermore, unlike scientific studies where variables are controlled for, studies of students' progress are multifaceted and include several factors, often unrelated to the learning environment, that are difficult to measure.

So I find I am coming from a different perspective to that of most educational studies which are often more qualitative in nature. Furthermore, I am aware that my application of science type principles may have inadequacies in trying to identify the significant factors contributing to a multifaceted problem. I also find it difficult to box the problem that I want to address in a particular area of education theory and research. However, I have decided to follow a quantitative approach as an initial exploration as this is the most frequent way students are assessed, and realise that a qualitative study may be required following this.

I have been fortunate to be involved in the co-ordination of the Bioscience and SFP Biology courses during the past 8 years. During this period, I have kept a database of all tasks completed by students and their performance in these. This has provided me with the data that forms the basis of my study presented here. I have also been able to see that tasks performed in practicals, tests and examinations required similar skills over the years.

The myriad of issues discussed in the study and their degrees of interrelatedness reflect the complexity of the problem and the difficulties in identifying main factors affecting student performance. I hope the present study encourages others to investigate courses they are involved in and how students' marks reflect performance and learning. I think curricula would benefit from such studies and issues related to students' learning may become clearer, particularly in the South African tertiary education scenario in the Life Sciences.

CHAPTER 1

FACTORS INFLUENCING LEARNING

There has been a movement towards a more progressive and relevant education system for a democratic South Africa, especially since the 1994 elections. However, despite the changing of laws, the impact of the previous system continues to be felt. In particular the sciences are affected. Since the mid 80's controls have been relaxed on student admission to traditionally white universities (Rutherford and Watson 1990). Despite this, the number of black students majoring in Science subjects, in particular the Life Sciences, remains very low (Rutherford and Watson 1990, Rutherford and Donald 1993, Downs and Drummond in press). The graduate profile in science shows an under representation of Blacks (FRD 1998). Consequently there has been a strong thrust towards developing science through education policy. At tertiary level, the question is whether this should be addressed by largely structural changes eg. by adding on a course which helps shape students, or more far reaching changes eg. examination of curriculum and curriculum reform.

Bioscience is a prescribed first year course at the University of Natal that feeds students into the Life Sciences. However, few Black students continue into the Life Sciences study after their first year of Bioscience, and this trend includes a number of the Black students that register for Bioscience who have completed the Science Foundation Programme (SFP), an access programme designed to assist disadvantaged students study science at a tertiary level. This lack of Black students within the sciences is a matter of concern.

One attempt towards addressing the paucity of Black graduates, and the associated socio-political and economic deficiencies in South African Education, the SFP was launched in 1991 at the University of Natal (UNP). The SFP is a year programme that precedes entry into the Science faculty. The educational philosophy adopted by those involved in the development of the SFP (Grayson 1993, 1996) was based on constructivism (Vygotsky, in Bereiter 1985, Slavin 1997) and skills based learning (Driver and Scott 1987). The intention was that learning should lead to the development of lifelong learners (Ramsden 1992). The goals and learning outcomes of the SFP are to develop the background knowledge, skills and confidence of these academically disadvantaged students so that they are able to successfully complete tertiary studies in science

(Grayson 1993, 1996). These considerations influenced the design of the courses/modules (Chemistry, Mathematics, Physics, Biology and Academic Communication) offered as a package and also encouraged exchange across these disciplines. Each course was envisaged as a developmental one progressing from basic concepts to more difficult ones with skills development a key factor throughout (Grayson 1993, 1996). The intention was not to pre-teach first year courses nor offer courses that were content based. Students eligible for this access course were previously disadvantaged, English second language students with insufficient points to enter the Science Faculty (Grayson 1993, 1996). The SFP curricula do not have an effect on the main curricula except indirectly (pers. obs.).

Reflection showed that despite the SFP, few of these students were enrolling for a degree in the Life Sciences and a number of those who did were struggling with first year Biology/Zoology. We initiated a study into the factors causing this. The results showed that most factors were external to the university and the SFP (Downs and Drummond in press) further showing the complexity of the problem. Assessment using a marine theme questionnaire revealed that SFP students were embarking on their studies in Biology with a very poor general knowledge and a limited natural history background. Students also showed poor comprehension and writing ability (Downs *et al.* 2000). Such information, has as yet, not been fed into the main curriculum in a structured manner (pers. obs.).

Background knowledge of natural history of pre- university and first year university Life Science students at various tertiary institutions in KwaZulu-Natal revealed poor background knowledge among English second language Life Science students, particularly the SFP students at UNP (Downs *et al.* 2000). The study showed that improvement in the SFP students' performance following a marine enrichment programme suggests that while poor background biological knowledge can be enhanced, factors such as financial and personal problems external to the course also affect progress (Downs et al. 2000).

Problem Identification

Inadequate background knowledge is a prime contributor to the poor achievement and low retention rate of second language students in the Life Sciences. Students' current knowledge plays a critical role in any intellectual activity. In courses where there are a majority of disadvantaged students, perceptions and engagement of these students may reflect their poorly developed cognitive skills or an ill-matched curriculum. Consequently, despite the best intentions of the course, they are unable to engage and thus perform poorly in a major proportion of the assessment tasks. However, the focus on "disadvantaged" students may obscure broader issues that are more important for a particular course as a whole. For example, if a course's objectives are not linked to the assessment, poor performance of all students is likely. The latter requires curriculum changes for improved student performance. Given the influence of assessment on the education process, the development, form and processing of assessment may all contribute to the problem. Furthermore, it is crucially important that assessment is considered in terms of its fairness for all as a measure of achievement (Gipps and Murphy 1996).

The focus of this study was to examine trends in performance of all students in the assessments in Bioscience at the University of Natal, Pietermaritzburg, to see if there were any identifiable groups who were having problems, and if there were any patterns emerging in differential performances between these students.

Accordingly, the following critical research questions were addressed.

CRITICAL RESEARCH QUESTIONS

Key question: What is the implication of student performance in assessment tasks for the curriculum of the Bioscience course?

1. Are there any differences or patterns noticeable when examining the performance of students studying Bioscience at the University of Natal, Pietermaritzburg over 5 years?

2. Is there a difference in the Bioscience performance between SFP, ESL and other student groups at UNP when assessed across a range of tasks? What is the extent of this difference?

3. What is the effect on student performance of combining different assessment task marks and their respective weightings?

Related sub-questions:

1. How does SFP student performance in a range of different assessment tasks compare with other first year students in the Life Sciences, specifically Bioscience?
2. How does SFP student performance in a range of different assessment tasks compare across

the years (1995-2000) at the SFP Biology level?

3. What is the correlation between students' SFP biology marks and their Bioscience marks?
4. Is there a difference between how SFP students perform in practical tasks compared to theoretical tasks compared with other Bioscience students?

The above are addressed in the following Chapters, which are presented in the format for submission to the International Journal of Science Education.

As the Science Foundation Programme provides an important route for disadvantaged students to qualify for first year studies, I have particularly analysed the performance of this group of students in their SFP Biology.

As someone involved in the teaching of biology at first year and SFP levels, I have found that it is difficult to determine if students' poor performance is student related or curriculum related. I feel that it is often easier to blame the former. I feel that if most students perform poorly then it is mainly a curriculum issue. However, if only certain groups perform poorly then I raise the question of whether this is the effect English Second Language or the effect of previously disadvantaged education? I hoped that an initial exploration of students' performance would shed light on the main contributing factors.

South Africa has a need for science expertise but there is a dearth of students studying sciences, in particular Black students. The University of Natal, Pietermaritzburg Science and Agricultural Faculty has attempted to address the issues of second language and previous education disadvantages by providing SFP. As this is the main source of Black students entering Faculty, I am also interested in the marks that SFP Biology students obtain and whether the final mark can be used as a predictor of students' future performance or do they hide areas of weakness that inhibit students at a later stage in their tertiary studies. I am interested in whether the factors affecting these students' performance are related to the first year Bioscience course, or

SFP or the interface between the two courses.

In the present study, I have examined students' marks in Bioscience 110 at the University of Natal, Pietermaritzburg, to determine if these reflect the trends in students' progress. I was interested to find out if subgroups of students within the class showed performances that mirrored one another possibly suggesting the need for curriculum change. I firstly examined how the whole assessment reflected in a final mark gave a general idea of students' achievement over several years. In addition I examined whether this showed trends between the various groups of students that formed subsets within the main student body. These groups were classified as Science Foundation Programme (SFP) students, Black, Indian and White coloured? That reflected the previous apartheid education segregation, with the former two groups also classified as most disadvantaged and mostly second language students ie. these represented levels of students. Although segregation policies have been abandoned, the deprivation of earlier times together with the associated poor education facilities that affects the quality of education, will take time to rectify. So universities cannot draw on well trained/ prepared secondary pupils from this broad sector. As a consequence there is a broad variation in the learners at the level of a first year course. Cognisance of the range of knowledge and abilities of the learners' affects the level of the course and expectations of the students. However, issues such as standards and level of competence to proceed to higher level courses often dominate the course structure and assessment.

If one is looking at the prediction value of a single final mark for a student, one also has to examine the various component marks that contribute to this. I think there are few studies of this in examining the actual impact of the course on its learners. I try and question the notion that variety in assessment types results in a final predictor mark or whether it indicates from students' performance trends where there are problems. Other areas that have troubled me are whether marks reflect the integration of theory and practicals, and whether tasks are authentic in both. The latter is a study in its own and so I have not attempted to investigate it in the present study but I feel it is an important area for further research.

Another area that concerns me is how conceptual development is reflected in marks obtained and whether student performance actually reflects conceptual understanding. I feel misconceptions are often not identified during the assessment process and followed up with students. I have chosen not to explore this in detail in the present study but again feel that it is an important area for further study.

My biggest problem examining performance of students is that this is generally reflected by a mark and although the marks can be categorised as being for practical or theory tasks, there is a limit to the value of a mark in identifying the task and its difficulty or the students' problem. This makes initial quantitative methods appropriate. Furthermore, by examining performance of subgroups in the class, I want to initially avoid the debate whether the previously disadvantaged students are adjusted to the curriculum or the curriculum to the students. Presently a model is used during the foundation year to change these students and prepare them for tertiary study.

Part of my involvement in SFP Biology and Bioscience was to collate the marks of any assessment done and be responsible for the calculation of class, examination and final marks. I have used this data in the present study to establish any trends.

THEORETICAL FRAMEWORK

Studies of performance typically identify social class, ethnic group or gender as factors that account for variation in performance (Gipps and Murphy 1996). There is little published research into examination practice at tertiary level in terms of the questions asked and the procedures used (Gipps and Murphy 1996). Most studies of students' performance at tertiary level detail the throughput of students (Rutherford and Watson 1990, Rutherford and Donald 1993). There is some information on the gender differences in degree performance (Gipps and

Murphy 1996). In the debate around students coping with science subjects, at the tertiary level little research has been conducted on the contribution of assessment tasks to a final grade awarded to students.

Students' performance in a science course is directly linked to the assessment and closely allied to the teaching of that course. These all fall under the umbrella of the curriculum of that course. Consequently, I chose to use curriculum as the broad theoretical framework that the above questions are addressed. In addition, if curriculum is the central focus, then I feel that we need to view the patterns obtained of student performance in the light of what curriculum changes are required. This questions how we teach and assess and what factors affect students' learning. So I have included discussion of curriculum development, assessment, learning, and the language of Biology. These are each discussed below as a background to the study.

Which Curriculum Paradigm?

The notion of a paradigm and its definition is much discussed (Frame 1996) but the usage here will follow the description of "a conceptual framework of values and rules that guide inquiry" (Schubert 1986). It has two main uses with respect to curriculum: what kinds of topics are covered and how methods of inquiry are used (Schubert 1986). Curriculum paradigms are generally identified as those of practical inquiry (empirical (analytical), hermeneutic (interpretive) or critical (emancipatory)) based on Habermas's theory of knowledge (Schubert 1986) although there are others (religious and postmodern) (Doll 1993). Currently the Bioscience 110 course is more empirical.

Few of the defined curriculum paradigms take into account the nature and development of the multiple intelligences of the learner as described by Gardner (Mettetal *et al.* 1997). Traditionally curricula in the Science Faculty UNP emphasise verbal and logical-mathematical skills, yet an overview of most curriculum outcomes include other skills such as interpersonal abilities (Mettetal *et al.* 1997). This may affect student performance in assessment tasks in the present Bioscience course.

Curriculum

Curriculum should be viewed holistically. Curriculum development should follow a cycle of reflection, planning, implementation and evaluation (Luckett 1995). In discussions of curriculum those teaching a course need to identify whether this

- includes all aspects of the curriculum (structure, process, topics, outcomes, and asessment) including the syllabus.
- consider who needs to be involved in the discussion
- and what structures and constraints require identification.

The cycle of curriculum development is of particular importance in the light of the key question: "What is the implication of student performance in assessment tasks for the curriculum of the Bioscience course?". The outcomes and assessment impact on SFP and the mainstream course so it is especially important that discussion of the "who" and "how" of the teaching takes place in conjunction and not in isolation. It is good to question how the assessment reflects the way the courses are taught.

Various questions may be raised about curriculum changes in a course over years:

- is it flexible?
- does it take into account the students' abilities, background and perceptions?
- is it short changing students when reducing content?
- how is it affected by the globalisation of knowledge?
- is it developing values as outlined in the outcomes?
- is it contextualising parts of our courses using local examples?

Bias in the curriculum and access to learning, both of which interact with teacher expectation are important in how an individual or group achieves (Gipps and Murphy 1996). To ensure that assessment practice and the interpretation of results is as fair as possible for all groups, a broad review of the syllabus content, teacher attitude, assessment mode and item is necessary (Gipps and Murphy 1996). An example where assessment may be impacting on students' performance is in the area of essays where staff may not be discussing the criteria used in marking and consequently the marks reflect lecturer bias rather then students' comparative ability. This would affect some students' performance greatly if essays contribute a large proportion of the final mark.

Curriculum development

When examining a course, a number of questions should be considered:

- is there new content or processes?
- is there a need to make changes?
- what is worthwhile knowledge and experience?
- are the core courses fundamental in their knowledge for the discipline or essential to the university's mission and goals in respect of undergraduate teaching (Frame 1996)?

There has been some attempt to develop the curriculum of the Bioscience 110 course. It is a course taught in the School of Botany and Zoology (SBZ), UNP. There has been a move within the SBZ over a number of years to move from content based, lecture dominated courses to more skills and student oriented/centred courses. There is an integration of the theory and practical work. However, there is a minimum content knowledge that is basic to each module if students are to achieve the outcomes of the module. This raises further questions:

- What system does the SBZ have in place to determine the minimum content knowledge a module must develop or cover?
- How does the SBZ prevent an imbalance between content knowledge learning versus skills development in a module or across a programme?
- Should the types of assessment favour one of these more than another?

Despite the curricula changes undertaken, little has been changed in terms of assessment and its impact on students' performance. In particular, there is a need to examine the implication of student performance in assessment tasks for the curriculum of the Bioscience course.

Some Schools at the University of Natal have developed radical and different approaches to the curriculum of the programmes that they now offer. An example is the Medical School who hope that they have developed a new curriculum where students are responsible for their learning and that their learning is contextualised. In the SBZ, there needs to be consideration of whether there is a new approach that could be developed to create a curriculum that is more vocational and contextualised.

The development of thinking skills is often the major goal of teachers but students are often oblivious to this (Adams 1989). It is generally assumed that for any curriculum developing thinking, there exists a certain set of skills or processes that are common (Adams 1989). These usually are categorised as macrological or micrological skills depending on approach. However, the questions of what works and why are not simple to answer (Adams 1989). In the present forms of assessment tasks currently used, the levels and degree of thinking and skills needs to analysed. Bioscience teaching staff have managed to achieve levels and degree of thinking and skills in the practical classes during the course but it needs to be extended to all forms of assessment in the course.

Holistic views of teaching, learning and assessment are important (Gipps 1994, Boud 1995). Constructivist development models have been advocated to improve this, particularly as they frame assessment with student progress towards the goal measured but support students in achieving these (Taylor and Marienau 1997). Developmental processes are a key element (Taylor and Marienau 1997). Although the intention of the staff that teach a course may feel they are viewing and running a course holistically, the reality may be different.

These holistic views incorporate the ideas of Driver (1988) who suggests that in implementing a constructivist approach to teaching and learning science a number of features need to be addressed. Firstly, experimental studies on concept change- analyses are needed to indicate the nature of conceptual change required in different areas of concern and then appropriate strategies devised and evaluated. The long-term effectiveness of strategies and the contexts in which the learning is useful to the learner need special attention in the evaluation. Secondly, longitudinal studies of conceptual development are required. Thirdly, metacognitive learning experiments and analyses are required to show how students can be encouraged to take responsibility for their learning both personally and within the learning environment. Fourthly, these teaching approaches need to be implemented to determine if they are of value to other teachers.

In terms of curriculum development, assessment and performance of students are seldom examined critically. To develop holistic assessment requires knowledge of the students' perceptions, an ability to design multifaceted strategies, manage the assessment process and assist students in developing knowledge of their learning (Boud 1995). The latter requires increased self and peer assessment (Brown 1999, Boud 1995, Fullerton 1995). However, the move to modularisation of courses and the class size makes this more difficult (Boud 1995, pers. obs.). This has implications on student performance in assessment tasks for the curriculum of the

Bioscience course. Furthermore, if the curriculum is structured to develop the 'deep' learning approach (Gibbs 1992), this requires searching for meaning and structural relationships. In this approach students tend to relate to a task, read widely, discuss with others, and personally get involved and satisfied with the subject (Benett 1993). The surface learning approaches of students tend to satisfy imposed assessment criteria and students treat the tasks externally. These students want exam questions that they can answer from their notes (Benett 1993). The latter is what most students are familiar with in our current context and many use this as a survival strategy (pers. obs.). Therefore, the type and format of testing is important as it has implications on student performance, their learning and curriculum development of the Bioscience course.

In addition, assessment can be used to identify what students have and have not learned and where they are having difficulties (Gipps and Murphy 1996). In this way it supports the teacher-learning process (Gipps and Murphy 1996). A test should sample behaviour and performance of students' that is representative of their overall achievement and skill development (Hopkins and Antes 1985).

Another factor affecting the curriculum and assessment is language. The language of assessment relates to the whole of assessment (Boud 1995). In particular, the way that tasks are written as well as the feedback may have important effects on the ability of students to complete tasks and to learn through the process, especially for those who are English second language students.

Ideally, if assessment of courses is to improve, especially if the student body includes English second language and disadvantaged students, teachers need to be able to monitor the status of students' conceptions (Hewson and Thorely 1989). It is widely accepted that students' current knowledge plays a critical role in any intellectual activity and that learning can be viewed as a process of conceptual change (Hewson 1996). Conceptual change will be illustrated by comments from students that show their metacognitive realm (Hewson and Thorely 1989). Both students and teachers need to address the processes of conceptual change (Hewson and Thorely 1989). Assessment should develop students which are self monitoring in the metacognitive mode and who are encouraged to think (Gipps 1994).

Despite all the good intentions of curriculum development, it is rarely possible to address the needs of the entire student population. I hoped that analysis of student performance in Bioscience would show if there are any identifiable groups who are having problems, and if there were any patterns emerging in differential performances between students. I hoped that the results would influence the curriculum development.

Assessment and objectives

Three assessment paradigms are prevalent in the literature: psychometric, contextual and personalised (Mabry 1999). The contextual paradigm is characterised by the following: curriculum sensitive test content, classroom settings common, both objective and subjective items, teacher scored, self evaluation important and the formative use of results which may be summative (Mabry 1999). The primary distinction of this paradigm is that the content of assessment reflects curricula students actually experienced and so is designed to measure what students have actually learned (Mabry 1999). There are problems particularly with the scoring method, which is subjective, and so some variation in scores may be unrelated to the quality of student performance (Mabry 1999). The assessment of both courses (Bioscience and SFP Biology) to be examined in the present study falls in the contextual paradigm.

It is important that assessment practice is equally fair and sound for all groups of students (Gipps and Murphy 1996). Studies of achievement and the interpretation of these are dependant on the concepts and assumptions of achievement and how these are translated into practice (Gipps and Murphy 1996).

Promoting learning should be the aim of educational institutions and assessment is crucial to this (Black 1998). Evaluation refers to all the means used to formally measure student performance (Slavin 1997). This often includes academic achievement, behaviours and attitude. At most tertiary institutions in South Africa, students' performance is based primarily on graded tests (pers. comm.).

Three interconnected elements form the basis of any assessment; firstly the aspects of achievement that are to be assessed (cognition), secondly the tasks used to determine students' achievement and thirdly the methods used to interpret the evidence from the tasks (Pellegrino *et al.* 2001). This requires attention during course curriculum development. The present study has focussed on the grades obtained as an indicator of students' performance. In addition, the relationship between student marks and the forms of assessment have been investigated.

Teaching should be closely linked to instructional objectives, and both should clearly relate to assessment (Mager 1975). The greater the overlap between what was taught or learnt?

and what is tested, the better the student will score (Cooley and Leinhardt 1980). The evaluation of students must tell them which objectives they have mastered by the end of a course (Mabry 1999). In writing objectives and assessments, it is important to consider different skills and different levels of understanding (Slavin 1997). It is hoped that the patterns in students' performance in the present study will direct changes in the course.

Three perspectives have influenced assessment. Firstly, there is a behavioural perspective where behaviourist theories have influenced the curriculum and instructional methods with tasks in sequence from simple to complex so that students learn prerequisite skills before moving on to more complex ones (Pellegrino *et al.* 2001). Furthermore, there is a domain of knowledge that assessment indicates a student's mastery of. This perspective emphasizes how much knowledge a student has. Secondly, there is a cognitive perspective where cognitive theories that focus on how people develop structures of knowledge have influenced teaching and assessment (Pellegrino *et al.* 2001). These include the concepts related to a domain of knowledge and procedures for reasoning and problem solving (Pellegrino *et al.* 2001). This perspective emphasizes what type of knowledge a student has. Assessment of cognitive structures and reasoning processes generally requires complex tasks that display thinking patterns. This perspective emphasizes how much knowledge a student has (Pellegrino *et al.* 2001). Thirdly, there is the sociocultural or situative perspective where thought is not regarded as an individual response to task structures and goals but a response to a combination of practical activity, context and social interaction (Pellegrino *et al.* 2001). This differs to the cognitive perspective where focus is on individual thinking and learning (Pellegrino *et al.* 2001). The situative perspective proposes that every assessment is at least in part a measure of practice (Pellegrino *et al.* 2001).

Various taxonomies have been proposed to assist in categorising instructional activities, objectives and assessment. Bloom (1979) proposed a taxonomy of educational objectives where the objectives were ordered from simple to more complex tasks. These are as follows: knowledge (recalling information); comprehension (translating, interpreting or extrapolating information); application (using principles or abstractions to solve real-life problems); analysis (breaking down complex information or ideas into simpler parts to understand how the parts relate or are organised); synthesis (creation of something that did not exist before); and evaluation (judging something against a given standard) (Slavin 1997). In terms of assessment, this requires the form of the question type as well as the knowledge or skill tested both need to be considered.

Widely used forms of testing at tertiary level include multiple-choice questions (MCQ), short questions and essay type questions. Assessment forms vary enormously across disciplines and even within disciplines. Essay forms of assessment in tests can elicit a wide variety of responses from definitions to comparing and contrasting important concepts and events (Slavin 1997). These are especially suited for assessing students' ability to analyse, synthesise and evaluate. They allow appraisal of students' progress in organising data and applying concepts at the highest levels of instructional objectives. However, these essays depend heavily on writing skills and ability to phrase ideas and may underestimate the knowledge of a student who is a poor writer (Slavin 1997). Furthermore, there is difficulty in insuring reliability and validity in the marking of essays. Consequently some students may be at a disadvantage because of there their poor writing skills, yet the whole group may be affected by the marking process of essays if lecturers have not discussed the criteria to be used nor the level of competence required. Presently MCQ, short questions and essays are used to examine students as part of the theory component of the Bioscience 110 and SFP Biology courses.

There has been much criticism of testing especially of MCQs (Black 1998) with critics proposing, developing and implementing alternative assessment systems (Slavin 1997). In particular there has been emphasis on making assessment more authentic, and formative (Slavin 1997, Black 1998, Jacobs *et al* 1999). These are likely to require students to integrate knowledge from different domains (Slavin 1997).

The issues discussed above are important to the present study as they presently do not explicitly affect the way assessment of the Bioscience and SFP Biology are structured. It was hoped that analysis of student performance would identify where students were having difficulties. In turn, I hoped to determine the kind of demands being made on the student.

Assessment is intimately linked with equality and equity where teachers must strive for equal opportunity but must not expect equality of outcomes (Gipps and Murphy 1996). The concept of equity in assessment implies that the assessment practice and interpretation are fair and just for all groups (Gipps and Murphy 1996). However, other factors such as motivation, esteem and teacher behaviour and expectation also affect achievement (Gipps and Murphy 1996). Most of the hypotheses describing differential performance in students performance are either categorised as biological or environmental which imply that these differences are real (Gipps and Murphy 1996). However, differences may arise from the test itself, its administration or the teaching (Gipps and Murphy 1996). Sources of poor performance may be the test material content or the format of the task (Gipps and Murphy 1996). There is still much to be understood about the effect of coursework on performance (Gipps and Murphy 1996). Responses of students may reflect skills, knowledge or values irrelevant to the construct of interest eg. Content knowledge (when a test is intended to measure writing skill) or vice versa (Gipps and Murphy 1996). The assumption underlying assessment is that people of the same background knowledge and skills should perform in the same way irrespective of race, gender or ethnic group (Gipps and Murphy 1996). However, there is evidence of differential performance based on the following three subgroups: gender, social class and ethnic group (Gipps and Murphy 1996). There have been clear changes in the patterns of performance of minority groups in the UK but it is difficult to determine whether these reflect changes in achievement or changes in test (Gipps and Murphy 1996). Currently different forms as well as a range of assessments are used in both the practical and theory components of the Bioscience and SFP Biology in an attempt to test a diversity and range of skills and knowledge, and not disadvantage any students.

The language of Biology

Just as the way students are assessed affects them and their engagement, so too does language. Language plays an important role in students' understanding, learning and assessment. Students are seldom equipped with the reading and writing skills that the sciences demand and few are fluent in the "unique" languages of the sciences (Orr and Schutte 1994). These difficulties are even greater for those students for whom English is not a first language (Orr and Schutte 1994).

Traditionally, literacy was regarded as the ability to decode and encode various forms of script which allows individuals to function at higher, more abstract levels of cognitive functioning (Vygotsky 1978). Such an understanding led to the identification of literacy as a key factor in human progress and has led to a distinction being made between oral and literate cultures (Boughey 1998). This notion was challenged by researchers (recent ones include Street 1995, cited in Boughey, 1998) who discovered that it was schooling and not literacy *per se* that appeared to develop the ability to work on complex verbal reasoning tasks (Boughey 1998).

Miller (1997) also maintains that the critical factor underlying performance is not whether students are first or second English language speakers but extent of their academic preparedness. According to Rutherford and Watson (1990) and Miller (1998) academic achievement in the sciences is partly a function of the students' initial level of competence in terms of proficiency in English and Mathematics. Commitment and diligence are an essential component of academic achievement. The findings of Feltham and Downs (2001) reflect these findings in that, although SFP students did do better in those pretest tools that were not as language dependent as the open-ended questionnaire, generally the students' background knowledge bases were very poor. This poor background knowledge was clearly reflected in the pretests that demonstrated the students' inability to perform in the simple task of identifying drawings of marine creatures. Furthermore, students performed better on the specific rather than general biological knowledge questions.

Wood (1997) suggests that if the interpreter of a sentence has no general knowledge schemata component, additional problems with interpretation will be experienced over and above those concerned with the text structure. This will then affect their learning and potential in the assessment.

The relationship between different forms of assessment, language use and academic performance (within the context of under- preparedness), has been examined by Miller *et al.* (1997). Their study demonstrated that MCQs yielded higher marks than essay questions for both English first and second language learners. Although some researchers disagree (e.g. Bak 1990), MCQs have been accused of failing to assess little more than rote memory (Frederiksen 1984, Wright and Stanbrook 1986). It is evident that some students are more proficient at answering multiple choice questions using their skills of factual recall which they learned at school rather than answering questions that require some degree of linguistic competence (Scouller and Prosser 1994). Furthermore, although second language learners often complain that MCQ questions do not give them the opportunity to demonstrate their knowledge (Agar 1987 cited in Miller *et al.* 1997), it can be said that, since these tests do not require expressive linguistic skills, they are an advantage to ESL students (Wright and Stanbrook 1986). Indeed, as Moyo (1995) states, the theoretical assumption of language teaching is that reading comprehension should be taught before academic writing, suggesting that the latter is a more advanced skill than the former. This is a motivation for having multiple forms of assessment to determine students' overall final performance in courses such as Bioscience or SFP Biology.

Furthermore, in their comparison of English first and second language students with similar levels of " academic preparedness", Miller *et al.* (1997) demonstrated that although English first language students do consistently better than ESL students in essay assignments, (particularly those of a conceptual nature), there was no such difference in performance in MCQs. In some cases, ESL students perform even better in this form of assessment than their English-first language counterparts. This suggests that MCQ may be where these students perform best in Bioscience assessment tasks compared to the other students. Miller (1997) too, found that ESL students had difficulty in discriminating between good from poor essays in contrast to their English first- language counterparts.

Rennie and Jarvis (1995) have found drawings to be an effective means of exposing knowledge in those students who have limited language ability and for whom written expression may be a problem; other researchers regard multiple choice tests as valuable diagnostic probes in identifying misconceptions and deficiencies in background knowledge in clearly defined content areas (Treagust 1988, Duit *et al.* 1996). Some educators consider them to be the most useful and flexible of all test forms ((Ebel and Frisbie 1991, Gronlund 1991) cited by Slavin (1997)) and provide an opportunity for diagnosis of student knowledge and learning without the need for interviews (Duit *et al.* 1996). This has implications for curriculum development of Bioscience and within the constructivist framework of the SFP. In particular, the contribution of the different forms of assessment towards the final mark needs close examination in terms of teaching objectives and students' abilities. This is directly related to student performance in assessment tasks and its implications for the curriculum of the Bioscience and SFP Biology courses.

According to the Atkinson-Shiffrin (1968) model of information processing, meaningful learning occurs when new information is linked with previously acquired knowledge. This prior knowledge or background knowledge, is stored in networks of fact or concepts called schemata. These are structures that allow sense and order to be made of new knowledge and thus permit assimilation (Anderson and Bower 1983). Skemp (1962) has shown that schemata are essential for even the most straightforward tasks, and maintains that in any new field, the first schemata formed have lasting consequences for future learning in that field. Therefore, a comprehensive background knowledge on a topic suggests the existence of well developed schemata for incorporating new information (Schneider 1993). Slavin (1997) takes this further and maintains that background knowledge is even more important than general learning ability in predicting how much a student would learn. In the Bioscience course, there is a range of students from various ethnic backgrounds. The implication of this on performance in assessment tasks for the various subgroups needs investigation as it may have an impact on future curriculum development of the Bioscience course.

Learning is generally understood to entail changes in a learner's knowledge where such changes are attributed to experience (Lumpe and Staver 1995). Learning involving a conceptual change requires a dramatic restructuring of the existing knowledge base. This presupposes an existing knowledge base, developed often informally or intuitively through experience and interaction with the natural environment. These conceptions are often in contrast to prevailing scientific views and are termed misconceptions, alternative concepts and alternative frameworks (Abimbola 1988, Lynch 1996, Palmer 1999). According to Duit and Treagust, (1995) and Thijs (1992), naive conceptions show a marked resistance to change. Fraser *et. al.* (1998) have found that learners that have difficulty understanding scientific concepts, do not have the necessary conceptual, logical and linguistic background. Understanding these learning difficulties is a fundamental element in any educational activity, especially when the teacher comes from a community different from that of the learners.

Miller *et al.* (1997) state that there is a strong indication that the poor performance of under-prepared students remains consistent and that when they arrive at University, they are academically predisposed or constrained to maintain levels of achievement that seem resistant to radical alteration. Miller *et al.* (1997) state that curriculum reform may specifically target areas of poor performance (essay writing on conceptual topics in this case) in an attempt to provide students with the necessary competence to meet the kinds of academic demands that constitute university education.

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CHAPTER 2

INVESTIGATION INTO THE ACADEMIC PERFORMANCE OF FIRST YEAR STUDENTS IN BIOSCIENCE AT THE UNIVERSITY OF NATAL, PIETERMARITZBURG, WITH PARTICULAR REFERENCE TO ETHNIC GROUPS AND THE SCIENCE FOUNDATION PROGRAMME STUDENTS.

Introduction

There is growing concern nationally and at institutional level over the paucity of Black graduates in Science, despite the implementation of a number of measures to address this. The problem is a complex and multifaceted one. It may be helpful, therefore, to investigate the mainstream courses, and see how students are performing, and in particular how black students are coping. This study seeks to examine the trends in performance of different groups of students within the Bioscience course, with a particular emphasis on the SFP students and black students.

Performance of individual students in a course at a tertiary institution is usually reflected in a final mark that determines their progress and transfer to higher courses. Although, a single grade is not a good guide to each student's abilities, a set of grades obtained over several subjects may be a better guide (Black 1998). However, comparison between different subjects is fraught with technical difficulties. In a particular subject, comparison of students' final performance may be affected by range in educational and social backgrounds, rather than ability of students (Black 1998). Furthermore, some of the forms of assessment contributing to the final grade may need review if most students perform poorly in these. The certification of assessment raises several issues including: is the assessment effective in relation to its purpose (Black 1998)?

"All those responsible for education will claim to be committed to high standards" (Black 1998 p.144). There is a need to focus on what the tertiary institution's standards are and whether these have been reached. However, this raises many issues including the methods of scoring and the criterion levels chosen (Black 1998). The character of tests and the course need to be investigated if the latter are to be addressed. Comparisons require sophisticated interpretation (Black 1998).

There appears to be little analysis and comparison of student grades and performance over years in courses offered at tertiary institutions. There is little published research into examination practice at tertiary level in terms of the questions asked and the procedures used (Gipps and Murphy 1996). Most analysis has focussed on courses at secondary institutions. Furthermore, students' perceptions of assessment and its influence on their learning are important especially as assessment of students is a key factor in any quality improvement in higher education (Jacobs *et al.* 1999). The manner in which students are assessed and evaluated powerfully influences the ways in which they learn (Angelo 1993). Jacobs *et al.* (1999) highlight factors that influence students' perceptions of assessment:

- Failure to make assessment criteria explicit
- Failure to give clear instructions in the assessment task
- Inappropriate assessment methods (given the intended learning outcomes)
- Failure to provide students with detailed and meaningful feedback
- Failure to provide students with formative opportunities to practice the forms of assessment used formatively
- A lack of inter-rater reliability.

If a course's objectives are not linked to assessment, poor performance of students is likely.

The passing of the Bantu Education Act in 1953 (Buckland 1982, Behr 1984) has had severe consequences for generations of South African Black students at all levels of study. There has been a movement towards a more progressive and relevant education system for a democratic South Africa, especially after the 1994 elections. Despite the changing of laws, the impact of the previous system continues. In particular the sciences are affected. For each year from 1997-2000, numbers of students passing mathematics and physical science on higher grade were 4% and 5% respectively (Department of Education 2001). Of the 400 000 matriculation students that wrote mathematics in 2000, only 20 243 Blacks wrote mathematics and of these only 3 128 passed on higher grade (Department of Education 2001). Furthermore, there is a paucity of qualified teachers with 80% of mathematics and science teachers having a 3 year diploma without any specialisation in mathematics or science (Arnott and Kubeka 1997). There has also been a decrease in the number of students writing the matriculation examinations (Department of Education 2001). These factors impact on the number of students continuing in the sciences at a tertiary level, and the production of graduates in the sciences (FRD 1998). There is an under representation of Blacks in all fields of the few science graduates produced (FRD 1998). Since the mid 80's controls have been relaxed on student admission to traditionally white universities (Rutherford and Watson 1990). Despite this, the number of black students majoring in Science subjects, in particular the Life Sciences remains very low (Rutherford and Watson 1990, Rutherford and Donald 1993, Downs and Drummond in press). In 1990, the year before the inception of the Science Foundation Programme (SFP) at the University of Natal, Pietermaritzburg (UNP), of the 143 students which completed a B.Sc. degree at the University, only 6% were black (Grayson 1996).

In an attempt to address the paucity of Black graduates, and the associated socio-political and economic deficiencies in South African Education, the SFP was launched in 1991 at UNP. The SFP is a year programme that precedes entry into the Science faculty. It is designed to equip academically able, but under prepared black students with the skills, resources and confidence so that they are able to successfully engage with tertiary studies in science (Grayson 1993, 1996).

Reflection showed that despite the SFP, few of these or other Black students were enrolling for a degree in the Life Sciences and a number of those who did were struggling with first year Bioscience.

The focus of this study was to assess the performance of all students in a first year course, Bioscience at UNP. In particular, to determine if there were any identifiable groups who were having problems, and if there were any patterns emerging in differential performance between students. Of particular interest was performance, in the form of grades, of subgroups within the class especially English second language (ESL) students, and previous Science Foundation Programme (SFP) students. Consequently it was hoped that results from the study would be useful in curriculum development at both the SFP and Bioscience levels.

In the present study, performance trends in students' grades in Bioscience were examined. Firstly, these were investigated to determine how the whole assessment reflected in a final mark gave an indication of students' achievement over several years. In addition, the trends between the various groups of students that formed subsets within the main student body were investigated. These groups were classified as SFP students, Black, Indian and White which reflected the previous apartheid education segregations with the former two groups also classified as most disadvantaged and mostly second language students ie. these represented levels of students. (Note the SFP are mainly Black students). As a consequence of this broad variety in the learners at the level of a first year course, cognisance of the range of knowledge and abilities of the learners' affects the level of the course and expectations of the students. However, issues such as standards and level of competence to proceed to higher level courses often dominate the course structure and assessment.

It was hypothesised that most students in the Bioscience course (UNP) would perform poorly overall if there were issues related primarily to the course and its assessment. It was predicted that a small percentage of the class would perform well from year to year. Furthermore, it was hypothesised that there would be a difference in performance between the subgroups within the class. It was expected that English second language (ESL) students, in particular previous Science Foundation Programme (SFP) students' performance would be poor compared to other subgroups of first year students.

It was also hypothesised that the final aggregate mark is a poor reflection of performance. It was expected that students would perform significantly better in some of the contributing marks to the final aggregate. In an attempt to investigate this, the performance of the students was analysed to answer the following:

1. What is the implication of student performance in assessment tasks for the curriculum of the Bioscience course?
2. Are there any differences or patterns noticeable when examining the performance of students studying Bioscience at the University of Natal, Pietermaritzburg over 5 years?
3. Is there a difference in the Bioscience performance between SFP, ESL or other student groups at UNP when assessed across a range of tasks?
4. What is the effect on student performance of combining different assessment task marks and their respective weightings?

Related sub-questions:

1. What is the correlation between students' SFP biology marks and their Bioscience marks?

2. Is there a difference between how SFP students perform in practical compared to theory tasks compared with other Bioscience students?

METHODS

Student performance in first year Bioscience 110 course (a first semester module) at the University of Natal, Pietermaritzburg (an English language institution) was investigated to determine how students performed in the various tasks that contributed to the final mark. Comparison across years was also made. Data from 1995-2000 was analysed for the first semester. Full student sample sizes of between 200-300 for Bioscience students for each year were examined. To identify problems, students will be broadly categorised as past SFP students, with the remainder categorised according to ethnic group (Black, White (majority English first language speakers) and Indian students). The latter broadly represents student subgroupings in the class who came through the old South African apartheid education system.

Students' performance in class marks, theory and practical exams were compared. It was expected that in particular SFP students would perform most poorly in theory examinations that were composed of three sections namely Multiple choice questions (MCQ), short questions and an essay. The latter two types of assessment not only demand considerable English language competence on the part of students, but also challenge some high level cognitive skills for example, application, analysis, synthesis and evaluation (Bloom's taxonomy 1979). All comparisons were made using percentage values rather than absolute values.

Data Analysis

Student performance on individual questions and total scores were analysed using Repeated Measures Analysis of Variance (ANOVA, Statsoft, Tulsa) for validity. Bioscience 110 student performance data from 1995-2000 was compared using ANOVA. Students performance in class marks, theory and practical exams was compared using the student categories above using ANOVA and frequency distribution curves. Correlations between SFP Biology and subsequent performance in Bioscience were conducted. All statistical analyses were conducted using Statistica (Statsoft, Tulsa).

RESULTS

Final Bioscience 110 mark

The final Bioscience 110 marks obtained by students, excluding SFP, students are shown in Figure 2.1 for the period 1995-2000. Most students fall in the 50-59% category and the marks of the class were generally normally distributed.

When the final mark was examined according to student categories as follows SFP, Indian, White, Black and Coloured, it was found that all showed similar trends in performance with some groups performing more poorly compared with the others. Only the White students consistently had a mean final mark of 60% or above for the period 1995-2000 (Figure 2.2). SFP and other Black students tended to have a mean final mark of 50% or less (Figure 2.2). This is shown for the final mark in Bioscience 110 of SFP students (Figure 2.3) for the period 1995-2000. There was a significant difference in the final Bioscience mark of SFP students between 1995-2000 (ANOVA df = 5, 189; F = 5.24; P< 0.05, Figure 2.4a) with a general decline in the mean final Bioscience 110 mark. SFP students showed a decreased performance in Bioscience from 1995-2000 (Table 2.1). This is contrary to the final SFP Biology mark (Figure 2.4b) that shows that SFP students entering Bioscience 110 had similar SFP final marks each year. Furthermore there was no correlation between students' SFP final mark and their final mark in Bioscience 110 ($r^2 = 0.36$). There was a significant difference in students' SFP final mark and their final mark in Bioscience 110 (T-test; df = 146; t = 30.21; $P < 0.00$) suggesting this is not a good predictor of their Bioscience performance.

Breakdown of Final Bioscience 110 Mark

The final Bioscience 110 mark is a combination of a class mark, practical examination and a theory examination. The same content and skills were tested over the years. Comparison of class marks between 1995-2000 showed a significant difference (ANOVA; df = 5, 1622; F = 17.37; $p < 0.00$, Figure 2.5a). However, mean values were generally around 60%. There was also a significant difference in the practical exam mark (ANOVA; df = 5, 1596; F = 51.87; $p < 0.00$, Figure 2.5b). The mean practical examination mark declined in recent years. The theory examination mark was also significantly different between 1995-2000 (ANOVA; df = 5, 1574; F = 16.62; $p < 0.00$, Figure 2.5c). However, of importance was the general class trend across all groups was that the class mean mark was always below 50% showing that students performed poorly in this assessment task. When the class mark, practical and theory examinations were examined according to student categories as follows SFP, Indian, White, Black and Coloured, it was found that all groups performed poorly in the theory examinations (Figure 2.6). This implies that unless students had performed well in their class mark or practical examination, they were likely to fail. It appears that all students were affected.

When the theory examination was investigated further, it was analysed in its component parts multiple choice (MCQ), short questions and essay. It was found that the mean value for MCQ was similar between 1996-2000 and was generally about 60% (Figure 2.7a). In contrast students performed poorly in the short question and essay sections (Figure 2.7b, 2.7c). The different components of the theory examination were investigated further according to student categories (Figure 2.8). White students performed better than the other students. However the mean value for all student categories was below 50% for short questions and essay type questions. SFP students showed a decreased performance in Bioscience, in particular they showed poor performance in the theory examinations where they performed poorly in short questions and essays that require higher order cognitive skills.

All groups of students always performed best in MCQ and generally poorly in essay questions. Scheffe tests showed no significant difference between years ($p > 0.05$) but a significant difference between MCQ, and short questions and essay questions ($p < 0.05$). Overall means ($\pm$ SE, n=1319) from 1995-2000 for MCQ, short questions and essay questions were $60.0 \pm .46$, $37.1 \pm .43$ and $39.6 \pm .54$% respectively.

There has been an increase in students with lower SFP Biology grades choosing Bioscience (Downs unpublished data). This is reflected in their Bioscience 110 performance.

DISCUSSION

Generally the findings were predictable and similar outcomes have been reported particularly at a secondary institutional level previously (Gipps and Murphy 1996). These were:

a. Students who come from a non-English background do less well than native English speakers.

b. Students who come from educationally deprived systems fare worse than their more privileged colleagues.

c. For all groups, performance is higher on MCQ tests than open-ended ones.

As the teachers, the course and the format of assessment have remained unchanged during the period under review, the finding that performance drops off for successive groups of "similar" students appears real. Of interest is that all ethnic subgroupings of students show similar trends for the various assessment tasks. Broadly the assessment tasks can be divided into practical and theory. The practicals remained the same for the period of review and contributed 60% of the class mark. The practical examination questions were similar with only the specimens changing. Although the format of the theory examinations was the same across years, there was some variation in questions asked. However, all students performed poorly in this type of assessment. This has implications for the Bioscience curriculum, particularly the forms and tasks of assessment used in the theory component.

Very rarely at the tertiary level are pass marks looked at in depth. The comparison of scores expressed as percentages across years in the present study showed similar trends justifying the use of these. From a curriculum or teacher perspective this is useful information. Assessment is an important part of the learning process especially if the notion that the student is constructing knowledge is followed. Surveying the performance, as in this study, should hopefully inform one about how successful one's teaching is generally and in relation to the different ethnic groups. Learning is a curriculum issue, particularly how learning is integrated into assessment. Although the emphasis in Bioscience assessment is formative as well as summative, rather than just summative, the trends obtained suggest that all students have the same problems, just differing in degree. It questions how learning is integrated into assessment and also how students tackle learning. The latter raises further questions about the importance of background knowledge, prior learning and language.

Analysis of all 1st year Bioscience students: all and subgroupings

Most students' fell in the 50-59% category for their final Bioscience grade, however, when examined according to student subgroupings, SFP and Black students performed more poorly. As most students performed poorly, it appears that this is curriculum related. For SFP and Black students performance may be additionally affected by student factors such as second language and poor background knowledge of the subject. However, as they show similar trends to the other students, it appears that language only exacerbates the problem already in existence. It is generally easier for staff to blame the students for poor performance (pers. obs.). If most students perform poorly then it is a curriculum issue mainly. However, if only certain groups perform poorly then it is a factor related to the subgroup which in the present study was either linked to the English Second Language variable or the disadvantaged variable. In general, the White students performed better in their final grades as well as in the various assessment tasks. This may reflect their advantage as English first language speakers and generally broader biological background knowledge. It may also reflect that they are more familiar with the scientific way of formulating knowledge. Yet as all groups showed similar trends in performance, there remains a need for overall curriculum reform.

Analysis of contributory assessment marks to the cumulative mark in Bioscience

The development of higher order cognitive skills in Bioscience does not appear to have been successful for any of the ethnic groups, particularly the SFP or other Black students, as all perform poorly in essay and short questions. More research is required to determine what is being penalised: the content process or the biological knowledge. As all student groups performed poorly it suggests that it is more than a reflection of some having difficulties being ESL students. However, the group of students who perform most poorly in Bioscience are predominately ESL language students (pers. obs.). The language of assessment relates to the whole of assessment (Boud 1995). In particular, the way that tasks are written as well as the feedback given may have important effects on the ability of students to complete tasks and to learn through the process (Boud 1995), especially those who are English second language students.

The development of thinking skills is often the major goal of teachers but students are frequently oblivious to this (Adams 1989), in particular if students are coming from a system that encourages rote learning. Further research is required to determine whether in the various assessment tasks, the thinking skills are actually developed and tested. It is generally assumed that for any curriculum developing thinking, that there exists a certain set of skills or processes that are common (Adams 1989). These usually are categorised as macrological or micrological skills depending on approach. However, the questions of what works and why are not simple to answer (Adams 1989).

The challenge to staff is not to test knowledge acquisition or be constrained by the marking process. Rather their assessment requires knowledge of the students perceptions, ability to design multifaceted strategies, manage the assessment process and assist students in developing their knowledge of their learning (Boud 1995). The latter requires increased self and peer assessment (Brown 1999, Boud 1995, Fullerton 1995). However, the move to modularisation of courses makes this more difficult (Boud 1995). The 'deep' learning approach (Gibbs 1992) requires searching for meaning and structural relationships. In this approach students tend to relate to a task, read widely, discuss with others, and personally get involved and satisfied with the subject (Benett 1993). Consequently these students want examinations that demonstrate their own thinking. This has implications on student performance in assessment tasks for the curriculum of the Bioscience course. Whereas surface learning approaches of students tend to satisfy imposed assessment criteria and students treat the tasks externally. These students want examination questions that they can answer from their notes (Benett 1993). It is found that Bioscience students fit into the latter category (pers. obs) so curriculum and assessment forms in the course have to encourage them to move away from this. Although the final mark is an accumulation of different grades from various assessment tasks, the final examinations contribute the most and this is where students perform poorly.

Ideally, if assessment of Life Sciences courses, are to improve, especially if the student body includes English second language and disadvantaged students, teachers need to be able to monitor the status of students' conceptions (Hewson and Thorely 1989). It is widely accepted that students' current knowledge plays a critical role in any intellectual activity and that learning can be viewed as a process of conceptual change (Hewson 1996). Conceptual change will be illustrated by comments from students that show their metacognitive realm (Hewson and Thorely 1989). Both students and teachers need to address the processes of conceptual change (Hewson and Thorely 1989). Assessment should develop students that are self-monitoring in the metacognitive mode and that are encouraged to think (Gipps 1994). Further research is required to determine how effectively the above are being transmitted to Bioscience students and to what extent effectively expressed.

Analysis of SFP student performance in 1st year Bioscience

Although the SFP students showed similar trends in performance to the other subgroups suggesting a curriculum problem, they performed more poorly. Following feedback from 1st year lecturers, SFP students have poor skills in the following areas: summarising, identifying key concepts, discussion, essay writing and comprehension (pers. comm.). In addition their biological language knowledge is poor. Most students have misconceptions about fundamental biological concepts. Further research is required to determine whether the teaching has not addressed these, nor the assessment. These problems were reflected in the students' poor performance in theory examinations that contributed a third of their final mark. Consequently if these students had not performed well in their class mark or practical examination, they had little chance of passing. The percentage of previous SFP students passing Bioscience has decreased in recent years. It appears that a greater proportion of students choosing Bioscience are those with poorer final SFP marks (Downs unpublished data).

Despite SFP students developing their biological conceptual knowledge during their foundation year (Downs *et al.* 2001, Feltham and Downs 2001), it appears that their cognitive skills remain poorly developed as they did poorly in theory tasks. This appears to be an area that handicaps them in their performance in first year Bioscience. It questions how much is achievable in the SFP year? It also highlights the need for curriculum changes in teaching, learning and assessment both at the SFP and first year Biology levels to determine the links and understand the broader issues. The patterning of performance across all subgroups in Bioscience suggests it is a curriculum rather than student issue. However, there are numerous factors including socio-economic factors external to the course that affect previously disadvantaged students performance at higher tertiary levels which need to be considered.

Further research into the cognitive development and conceptual understanding in English second language (ESL) students, in particular Science Foundation Programme (SFP) students, and course curriculum changes are required to improve their performance in their first year Bioscience at the University of Natal, Pietermaritzburg.

Acknowledgements

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Table 2.1. Performance of SFP and other students in 1st year 1st semester Bioscience 110 from 1995-2000.

	sfp1995	rest1995	sfp1996	rest1996	sfp1997	rest1997	sfp1998	rest1998	sfp1999	rest1999	sfp2000	rest2000
<19	0	1	0	1	0	0	0	1	0	1	0	5
<29	0	5	0	22	3	10	0	15	3	8	12	16
30-39	0	25	0	22	8	11	7	44	15	30	8	29
40-49	0	0	0	0	0	0	0	0	0	0	0	0
50-59	2	69	10	83	17	67	14	103	27	84	9	100
60-69	4	62	3	35	0	54	2	53	3	60	0	43
70-74	0	15	0	4	0	20	0	10	0	16	0	10
75-79	0	7	0	3	0	5	0	9	0	8	0	7
80-89	0	3	0	2	0	6	0	4	0	10	0	4
90-100	0	0	0	0	0	0	0	0	0	0	0	0
Total	6	187	13	172	28	173	23	239	48	217	29	214
pass rate	100	83	100	74	61	88	70	75	62	82	31	77

Further research into the cognitive development and conceptual understanding in English second language (ESL) students, in particular Science Foundation Programme (SFP) students, and course curriculum changes are required to improve their performance in their first year Bioscience at the University of Natal, Pietermaritzburg.

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80-89	0	3	0	2	0	6	0	4	0	10	0	4
90-100	0	0	0	0	0	0	0	0	0	0	0	0
Total	6	187	13	172	28	173	23	239	48	217	29	214
pass rate	100	83	100	74	61	88	70	75	62	82	31	77

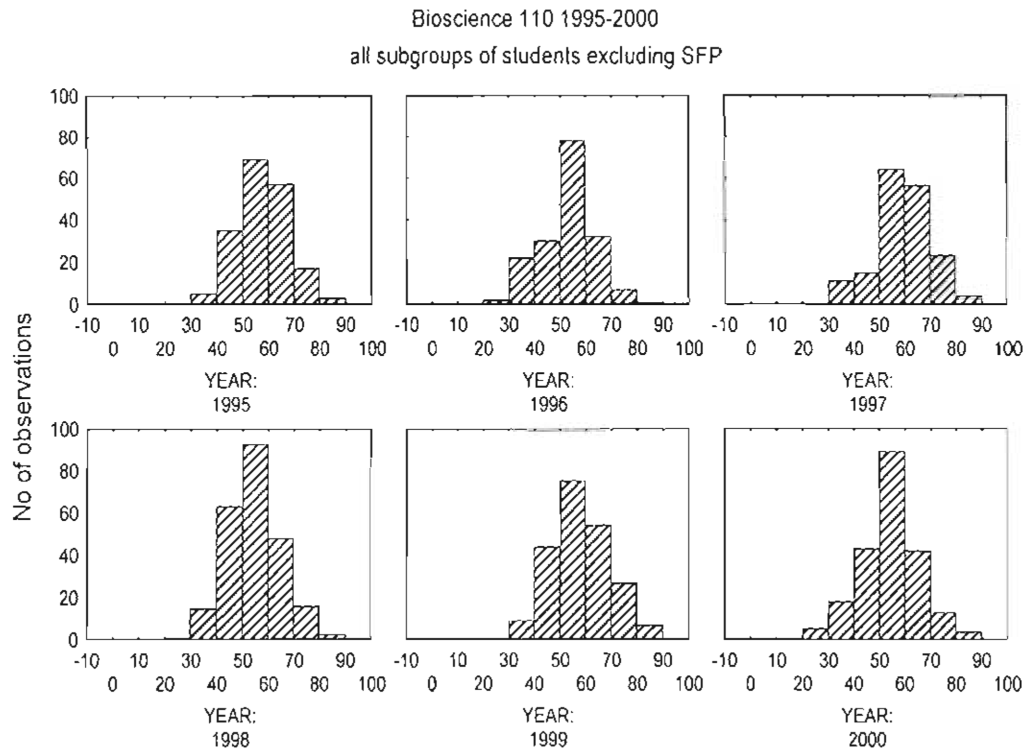


Figure 2.1. Final Bioscience 110 marks obtained by students excluding SFP students for the period 1995-2000.

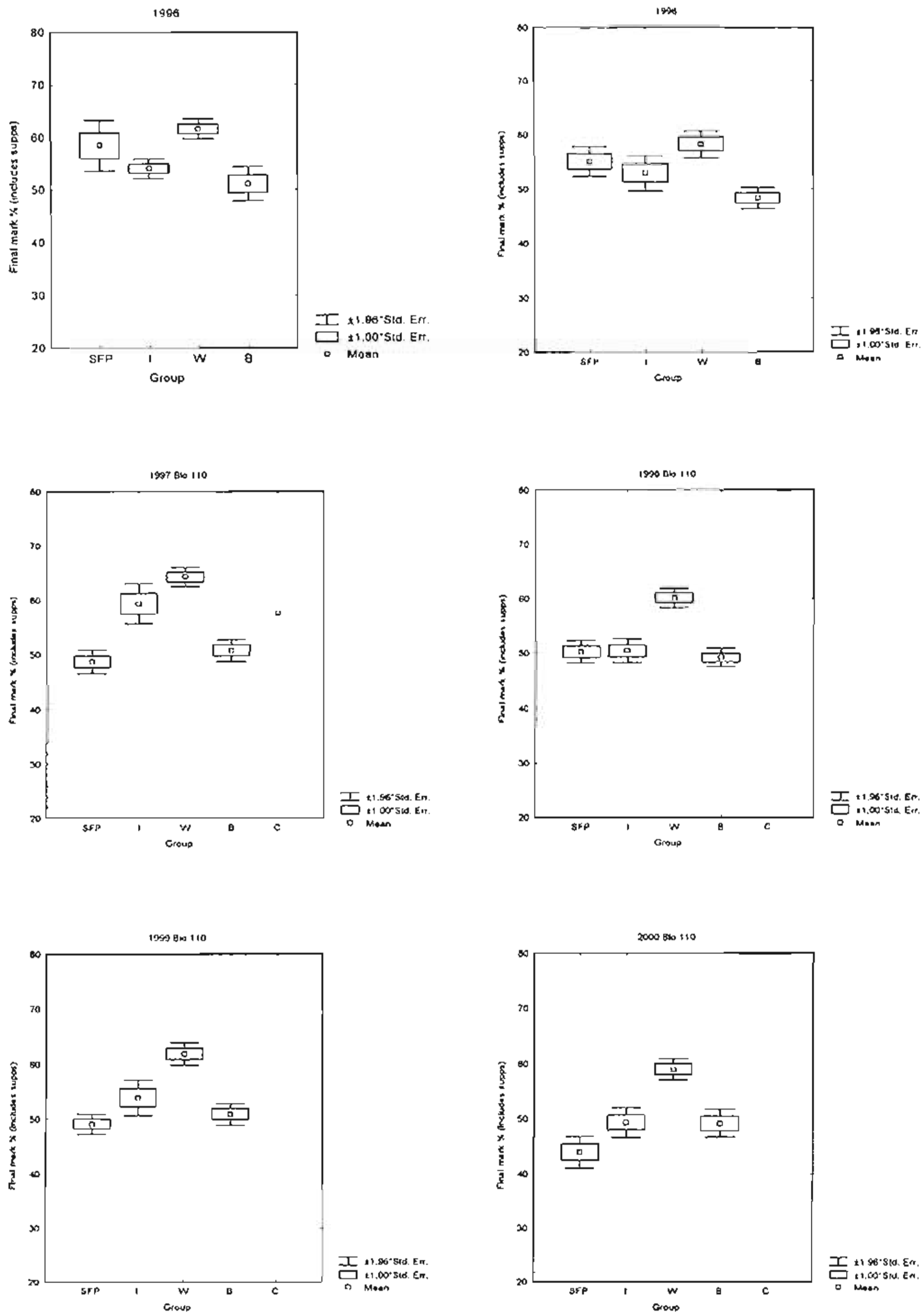


Figure 2.2. Final Bioscience 110 mark examined according to student categories (SFP, Indian (I), White (W), Black (B) and Coloured (C) for the period 1995-2000.

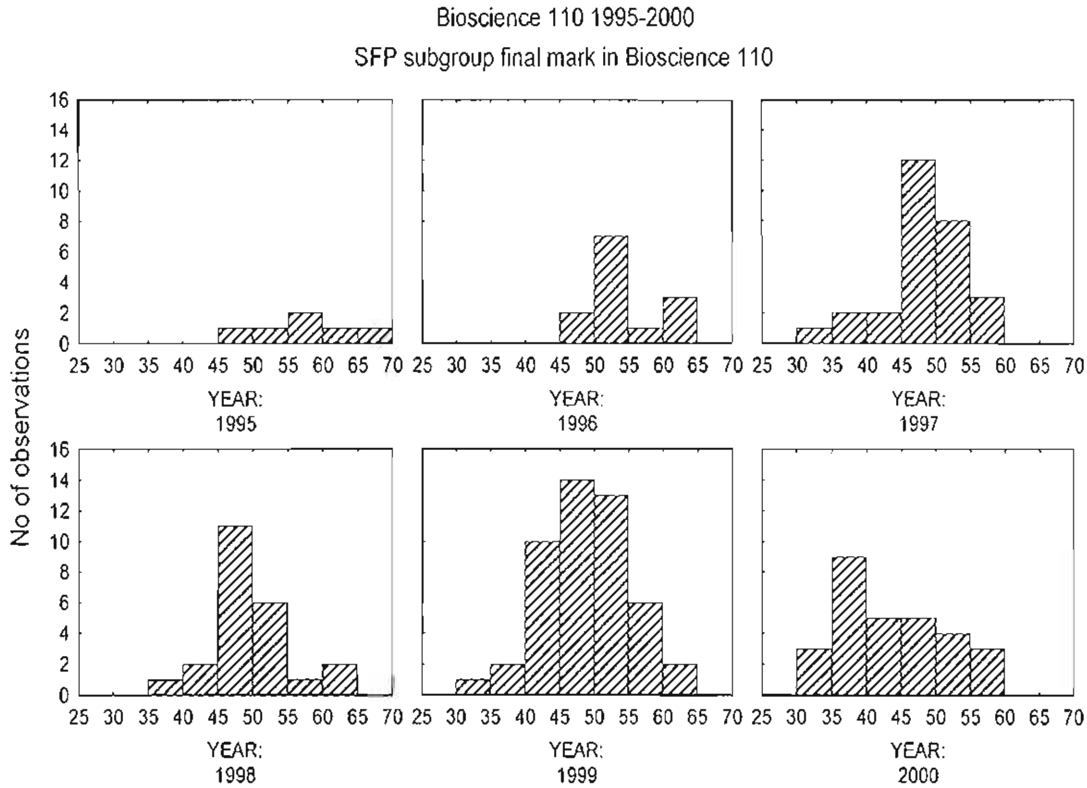
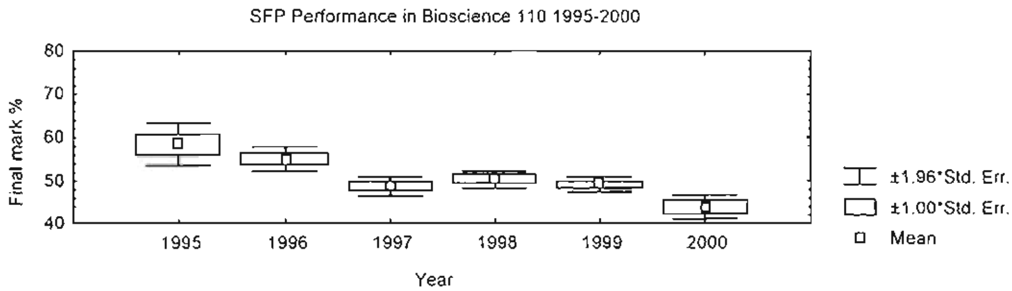


Figure 2.3. Previous SFP students final mark in Bioscience 110 for the period 1995-2000

a.



b.

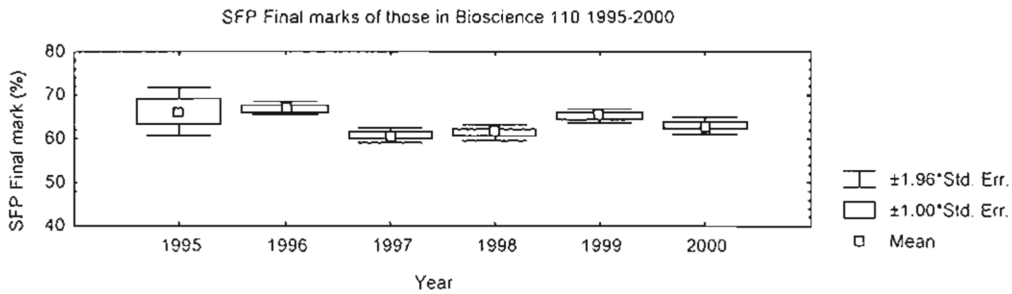


Figure 2.4. a. Final mean Bioscience 110 mark of previous SFP students between 1995-2000. b. Final mean SFP Biology mark of the above students.

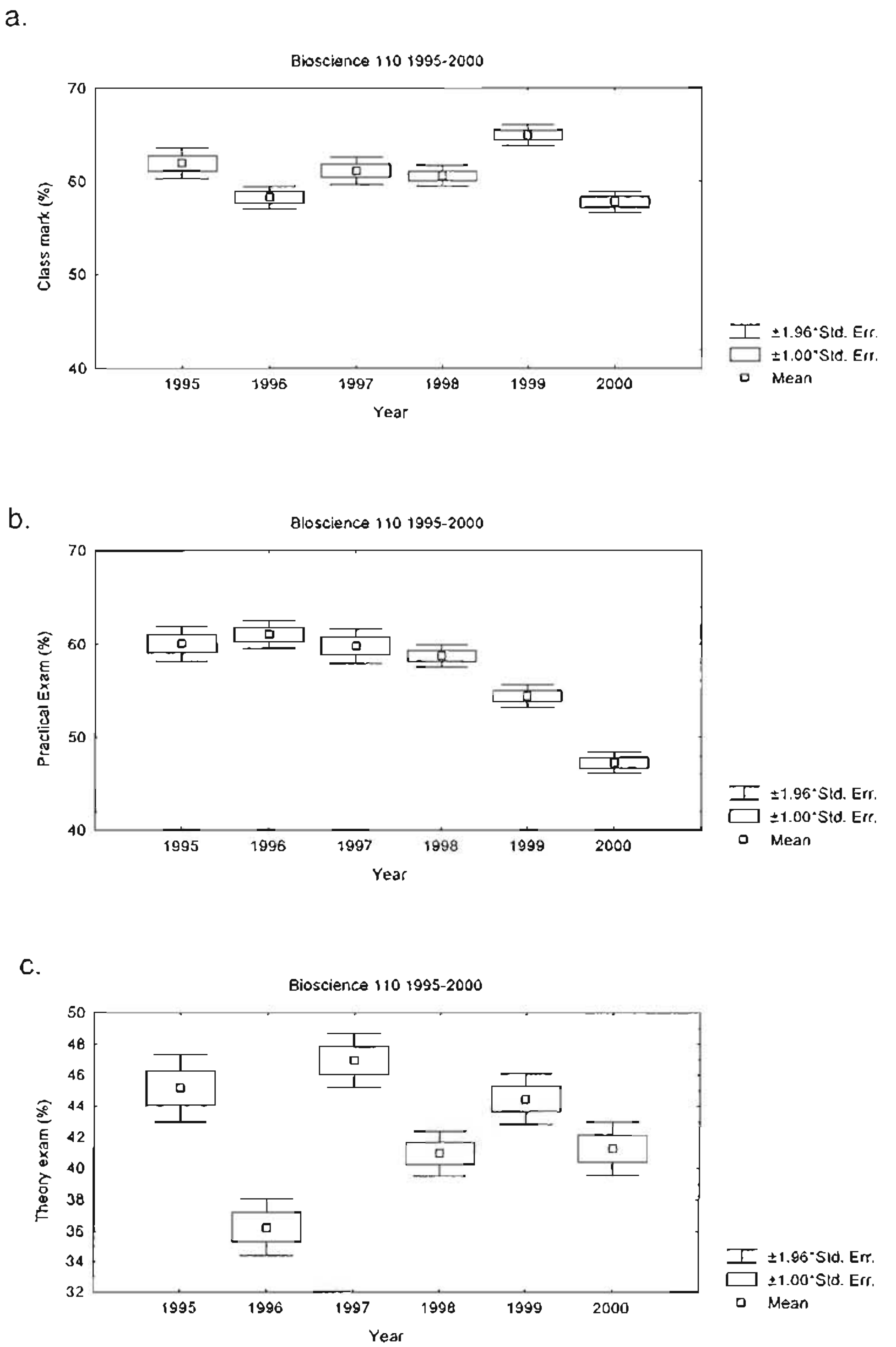


Figure 2.5. Comparison of the components of the final Bioscience 110 mark that is a combination of a. class mark, b. practical examination and c. theory examination for 1995-2000.

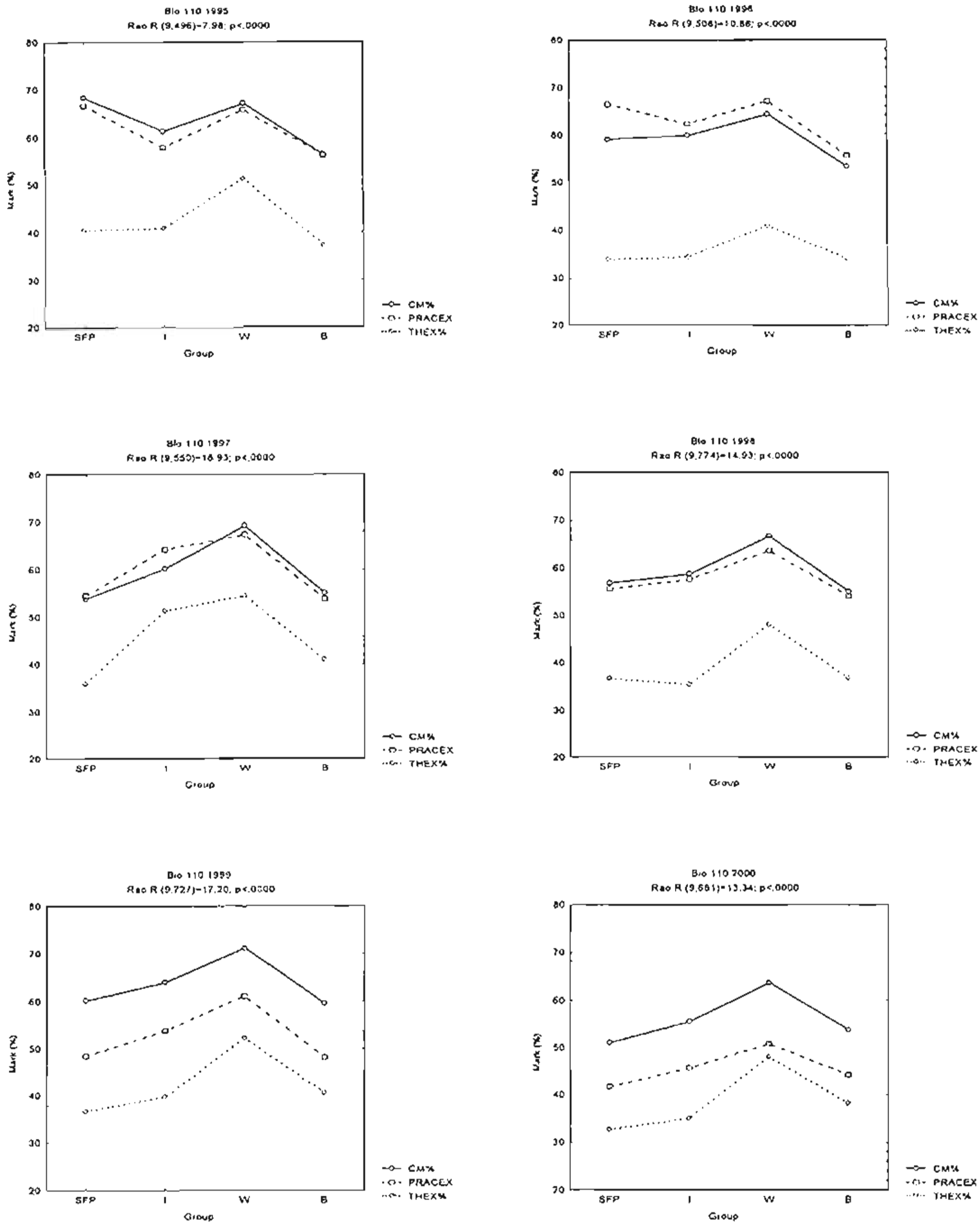


Figure 2.6. Components of the final Bioscience 110 mark (class mark (CM), practical examination (PRACEX) and a theory examination (THEX)) examined according to student categories (SFP, Indian (I), White (W), Black (B) and Coloured (C) for the period 1995-2000.

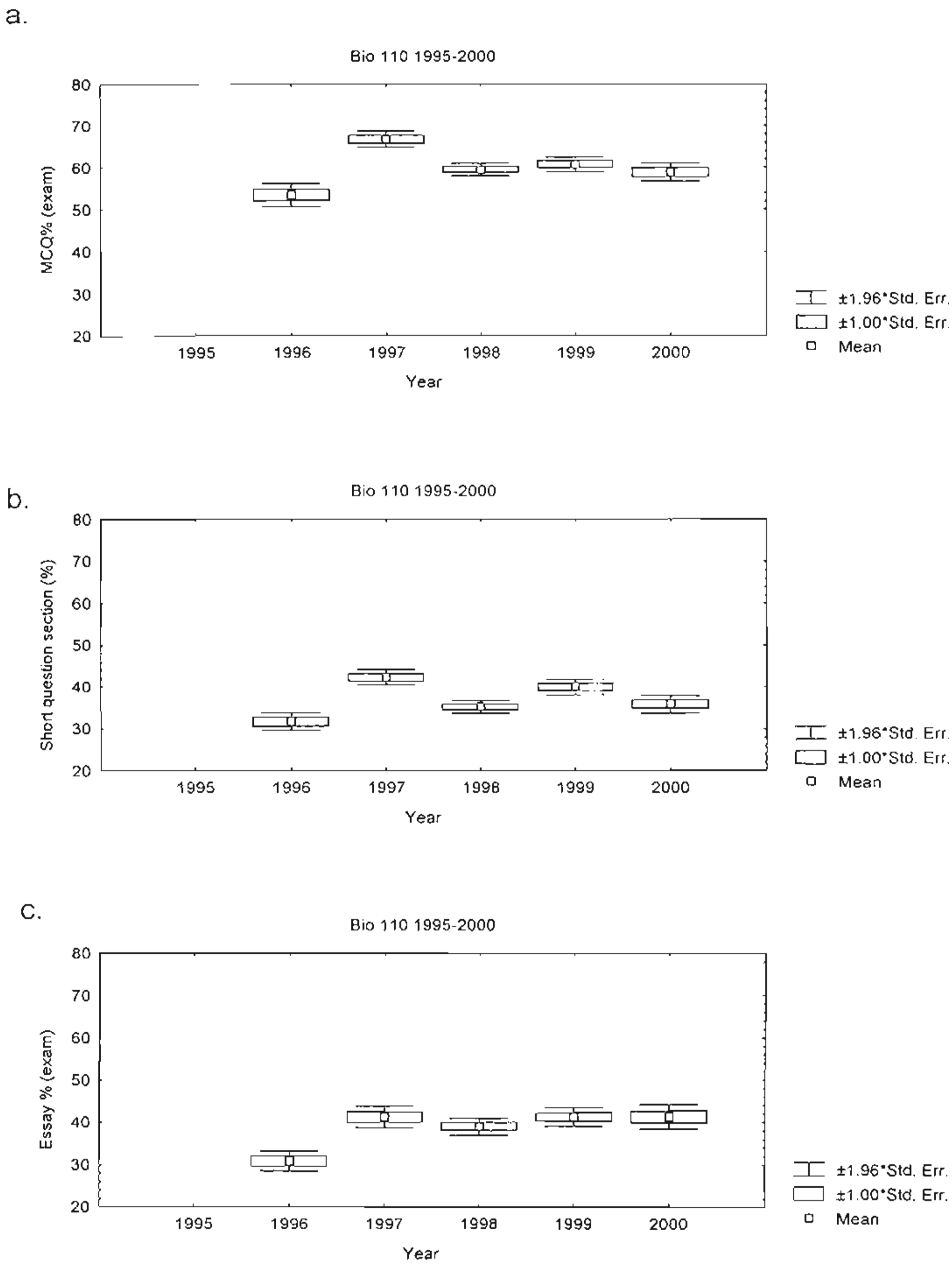


Figure 2.7. Components of the Bioscience 110 theory examination mark (a. MCQ, b. short question and c. essay) examined for the period 1995-2000.

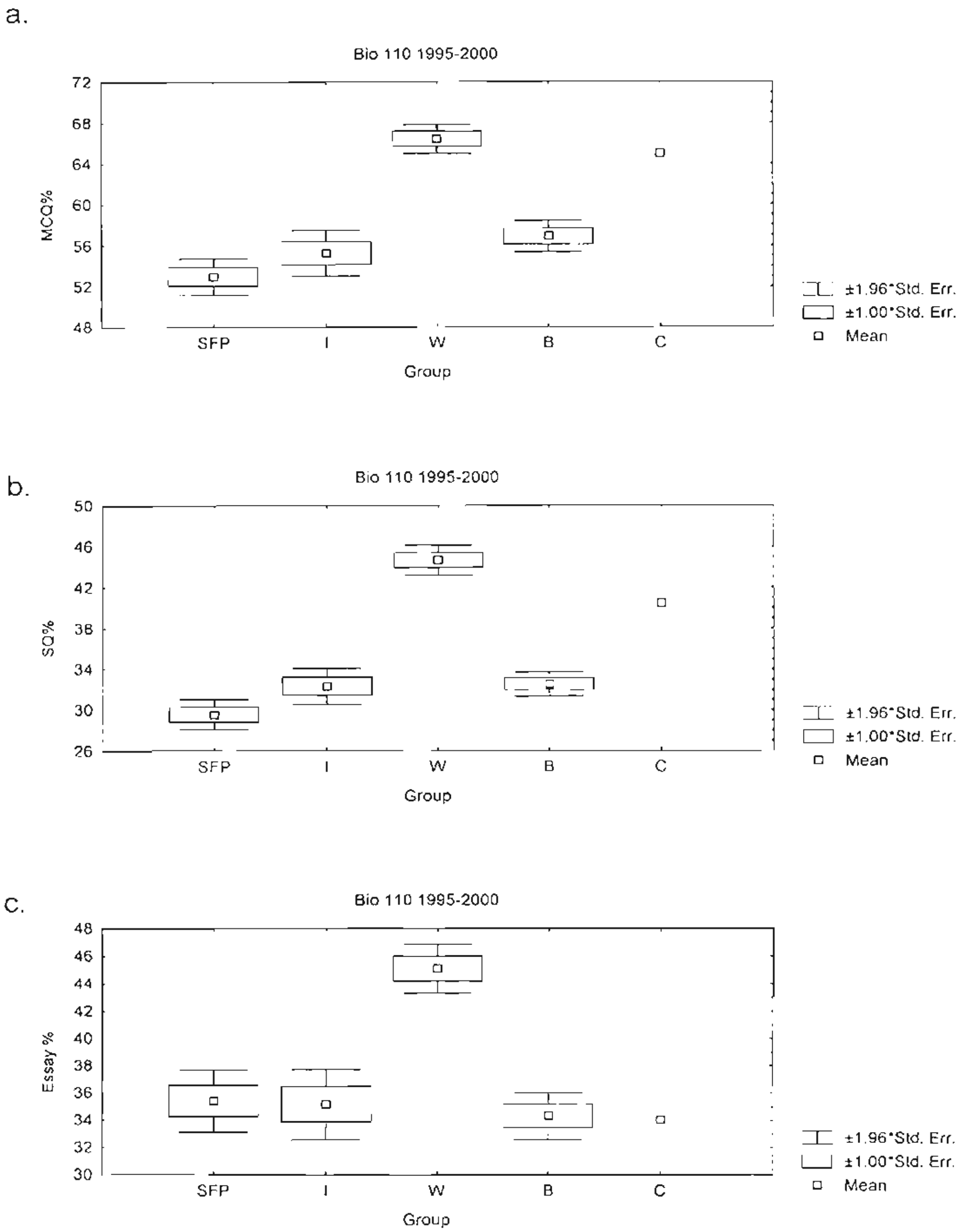


Figure 2.8. Components of the Bioscience 110 theory examination mark (a. MCQ, b. short question and c. essay) examined according to student categories (SFP, Indian (I), White (W), Black (B) and Coloured (C) for the period 1995-2000.

CHAPTER 3

HOW DOES THE PERFORMANCE OF SCIENCE FOUNDATION PROGRAMME BIOLOGY STUDENTS AT THE UNIVERSITY OF NATAL, PIETERMARITZBURG COMPARE ACROSS YEARS IN A RANGE OF DIFFERENT ASSESSMENT TASKS?

Introduction

It is a matter of concern at both national and institutional level that there are few Black students majoring Sciences generally. At the University of Natal, Pietermaritzburg (UNP), there is a particular concern about the lack of black students majoring in Life Sciences. One of the mechanisms that has been developed to address this issue is the development of the Science Foundation Programme (SFP) at the university. The SFP is a year programme that precedes entry into the Science faculty. It is designed to equip academically able, but under prepared black students with the skills, resources and self-confidence to embark on a science degree. Thus, in this study student performance in the programme was investigated, with a specific focus on how students performed in their assessments, across a range of tasks to see if any trends were observable.

Constructivists principles informed the development of the SFP (Vygotsky, in Bereiter 1985, Slavin 1997), as well as a focus on skills based learning (Driver and Scott 1987) in order to encourage deep learning, and develop lifelong learners. (Ramsden 1992). Assessment in such a course becomes integrated into the learning process (pers. obs.).

Pass rate is an indicator about a particular course at university. However, there is little analysis at tertiary institutions of student ability and the quality of a course in terms of teaching and assessment. The final mark that a student obtains for a course determines the student's progression to higher courses. This is of particular importance in foundation courses for disadvantaged students who would otherwise be unable to enter Faculty. There are also increased pressures from most university managements to obtain information that affects the viability and continuation of courses especially with regard to staff and course enrolment (Meade 1997).

When assessing the performance of students on a foundation course, it is important that students' final performance is of a standard to allow them to succeed at first year level courses, and that the course succeeds in its purpose of preparing students as well as developing them sufficiently. However, there are a variety of factors external to such a course that affect students' learning, development and performance.

SFP student numbers have increased from the initial 35 in 1991 to 140 in 2000 and 280 in 2001. In the first eight years of SFP, students gained access to the programme by completing a selection programme. In the past two years, matriculation performance and ability to pay for the course controlled access (students were able to apply for financial loans if their financial situation was very poor). This questions whether comparative analysis is possible, however as all students had lower than required university entrance requirements and were from educationally disadvantaged backgrounds. SFP students' access to Faculty is not guaranteed unless they achieve the minimum required grades designated in each subject.

Consequently the purpose of this study was to determine a) if the Biology SFP course resulted in a final mark for a student that reflected their potential to cope with tertiary studies and b) how SFP student performance in a range of different tasks compared across years (1999-2000) at the SFP Biology level. In particular, an investigation of whether SFP Biology assessment marks reflect the development of practical and cognitive skills was conducted. The use of different forms of assessment, as monitoring instruments, especially the patterns of grades awarded over a number of years was assessed. Effects of increased numbers of SFP students and range in ability of students were also investigated.

It hoped that trends found would assist in curriculum and/or assessment aspects of the first year Life Science courses, particularly Bioscience. Also any trends would allow comparison with those found in the Bioscience marks (Chapter 2). In particular, it was important to establish whether the trends found in the Bioscience marks were the same for the SFP or showeddifferent indications.

METHODS

Biology SFP Course Description

The course objectives, content, teaching, development and educational provision for disadvantaged students were investigated and summarised. This was based on the course outline and description of the module. This provided the background to the grades that were analysed. Assessment format was similar from 1995-2000. All comparisons were made using percentage values rather than absolute values.

Biology SFP Course Description

The course "Foundation Biology" (Biol 010) of the SFP is housed in the School of Botany and Zoology, UNP.

One of the main purposes of the course is to scaffold the development of science process skills in a biological context. The marine environment is used during the first half of the year as a source of content and materials. During this time, the students are introduced to some fundamental practical and cognitive skills necessary for degree study in the Life Sciences and to provide a foundation in biological concepts and awareness. In the second semester, this development of science process skills is continued using the plant kingdom and aspects of animal physiology as the source of material. In particular, students are familiarized with various aspects of plant biology.

The development of the students' investigative and communication skills is of vital importance as is the development of self-confidence and independence.

On completion of the course, it is hoped that the learning outcomes achieved by the students include an understanding and appreciation of marine organisms and the marine environment, and that they have acquired an understanding of some basic biological concepts; for example, the evolution of living things and the 3-dimensional nature of cells and tissues as viewed under a microscope. Students will hopefully have gained an appreciation of, and be able to discuss, the interrelationships that exist between biotic and abiotic factors. They will also hopefully understand and be able to explain some basic aspects of plant structure and function, and will have acquired an appreciation of the value of plants to humans. An understanding of various aspects of animal histology and physiology will also hopefully have been acquired on completion of the course. All of the above are assessed during the semester in practical and theoretical work.

With regards to specific learning outcomes, students will be able to use a compound microscope, calculate actual size of microscopic material and calculate magnification. They will have learned to make accurate and relevant observations and be able to prepare annotated drawings of macro and micro-biological specimens. It will be possible for students to differentiate between types of classifications and use a dichotomous key. Most importantly, they will have learned how to generate a hypothesis, conduct an experiment, illustrate, interpret and discuss results and prepare the resulting report. Furthermore, from a practical point of view, students will be able to prepare and annotate a plan diagram of a section through plant material.

They will be able to analyse text (identify key points), and summarize information by means of spider diagrams and concept maps. Interpretation of diagrams and figures will also be possible. Furthermore, students will be able to research a topic and write an essay discussing, with supporting arguments, their view on an issue. Not least, they will have acquired some skill in taking notes during lectures in preparation for the first year of their respective degrees.

Content

The content of the biology course is developmental; ie each topic prepares students for subsequent topics.

In the first semester the Marine Theme topic provides materials and context within which the tutorials, practicals and extra reading tasks are set. During practicals the emphasis is on students acquiring skills such as the use of dissecting and compound microscopes, preparation of wet mounts, annotated drawings and plan diagrams and the calculation of real size and magnification. Students are introduced to the plant and animal phyla through marine representatives. Tutorials cover topics including "What is Biology, What is Life, Mode of Life, Life's Six Kingdoms, Scientific Method, Classification, Fossils, Ecological Organization, Succession and Why cells are small". The extra reading tasks (one reading and set of questions each week) aim to improve students' general biological knowledge. Among the readings are, Life between the tides, Decorator Crabs, Marine Worms, the Plankton and the Echinoderms. A compulsory field trip to Isipingo Beach gives students an opportunity to put the Scientific method into action, by conducting an experiment, analysing data and writing a scientific report. Here, it is hoped that they also gain an appreciation for aspects of the abiotic conditions of the rocky shore environment and the adaptations of the organisms living there.

In the second semester the instructional mode becomes more formal. In preparation for first year courses, students are exposed to large classes and the lecture mode of teaching in the second semester. Lectures in the third quarter first introduce the evolution of vascular plants (trends toward specialization) to the students. Students are given incomplete notes that they add to. Lectures cover topics on plant diversity, plant structure and adaptations. Reproduction in plants is examined in detail and covers sexual and asexual modes as well as germination. Plant-water relations, in particular transpiration and the structure and function of tissues involved, are also covered. Students are given a choice of four essay topics to research the value of plants to humans. These topics include medicinal and ecological aspects of plants. These give students the opportunity to examine subjects as diverse as the influence of Man on Tropical Rain forests. The practicals investigate the processes of osmosis, plant tropisms, movement of water through a plant and transpiration (specifically, the effect of environmental conditions on the rate of transpiration).

In the fourth quarter students are required to make their own notes. Lectures deal with animal embryology and histology (focus is on the skin). Thermoregulation is covered in detail in that the general principles are examined, endoderms and ectoderms are compared and adaptations to heat and cold are investigated. Animal histology and metabolic rates are investigated in the practical sessions of this term.

Throughout the whole of second semester, much time is dedicated in the laboratory sessions to experimental methods and the associated report writing skills.

Assessment of outcomes

Assessment of the development of students' practical abilities is continuous throughout the year. Each student's practical is marked by a post-graduate demonstrator. The mark is recorded on a weekly basis. Assessment is used as part of the learning process in SFP

Biology. The tasks assessed were similar for the period of study.

At mid-year and year-end, the practical examinations include questions designed to assess students' microscopy, observation and drawing skills. The students' acquisition of process skills e.g. the ability to manipulate, interpret and illustrate data, accept or reject an hypothesis and draw logical conclusions is assessed using data response questions. The students' ability to make accurate and relevant observations is assessed in the preparation of detailed drawings and plan diagrams of plant and animal material.

The various essay and poster projects assess the students' ability to access and select relevant information, synthesize this information and present a logical argument, or an informative display (poster).

Conceptual understanding and reasoning skills are assessed in class tests and theory examinations using a range of direct questions, multiple choice, paragraph type and essay questions. These mirror the mainstream courses.

Grades and methods of assessment to be used in the module:

The first semester mark contributes 15% to the final grade and includes the following: first semester class mark (33%) (practicals (60%), theory assignments and tests (40%)), the June theory examination (33%) and the June practical examination (33%). The second semester class mark contributes 25% to the final grade and includes: practicals (60%), theory assignments and tests (40%). The November examinations contribute 60% to the final grade that is a combination of the theory paper (60%) and the practical paper (40%). The practicals remained the same for the period of review. The practical examination questions were similar with only the specimens changing. Although the format of the theory examinations was the same across years, there was some variation in questions asked. The weighting stated was imposed by University criteria.

Additional aspects of the course

Mode of teaching

The teaching methods used in the practical component of the module may be described as " hands-on". Students engage in skills based, guided discovery learning (students work in small groups with a demonstrator) during the laboratory sessions. Library work and field-trip experiments are central to investigative learning. The "hands-on" approach is also used in the field trips where students enjoy real biological experiences in groups, small enough to develop interest and promote communication and interaction with mentors and postgraduates.

The theoretical component initially takes the form of lectures run as tutorials. Individuals are expected to prepare for these tutorials that are followed by group discussion and individual consolidation through written exercises. Co-operative learning is facilitated through formal group work with the emphasis on peer teaching and individual accountability. Independent study is encouraged by the poster, research and/or essay exercises. A tutorial topic is scaffolded by relevant questions; direct learning results from group discussions that are then supplemented by readings and notes.

Students are helped during the second half of the year to adjust to the direct mode of lecturing in preparation for first year courses. These lectures are heavily supported by overhead transparencies, video and slide material. In the third term, an almost complete set of notes is made available to every student and they are expected to complete sections where asked and to supplement the notes with their own from lectures. In the fourth term, relevant readings and other articles of interest pertaining to the topic of animal physiology are given to the students, but they are expected to compile their own set of notes. During both terms, students are encouraged to ask questions and participate in discussion.

Independent study is further encouraged through the use of the manual to relate to practical and tutorial material. Pre-reading and preparation (for tutorials and practicals) is expected of the students.

Educational provision to support students from diverse/disadvantaged backgrounds

The entire programme is designed to accommodate the needs of disadvantaged students. Initially, the pace is slow. It later develops to a 1st year pace. Personalized attention is made available to the students in that groups of students are kept small (tutor or demonstrator to student ratio is 1:12). Focus is on the development of skills not the acquisition of facts and difficult vocabulary is explained during the lectures. Much attention is given to the development of the students' background biological knowledge that is initially poor.

Students receive frequent and comprehensive feedback in that practicals and assignments are marked weekly with comments and, if necessary, individual discussion of specific problems is carried out.

Expectations of student performance are made explicit from the start and, following on from this, the process and criteria for assessment are made transparent. Wherever possible teaching/ learning is made meaningful (accessible) ie. subject matter is constantly related to the students' lives or in context they understand. Building of self-confidence in students is important. Finally, comprehensive career guidance in the field of Life Sciences is offered.

As a consequence of the teaching philosophy adopted for SFP, the role of demonstrators in practicals is a major contribution especially in assessing the students work after each practical, providing feedback, encouraging discussion with students and assisting on field trips. Many of these demonstrators have acted as mentor figures to the students as well. With the increased numbers of SFP students, the role of demonstrators has become more crucial. In addition, the pre-practical preparation and management of demonstrators has increased. At the outset each year, demonstrators are given a general training and discussion course. Thereafter, they attend weekly pre-practicals and are provided with a detailed mark sheet to scaffold their marking and ensure standardisation of marking. Feedback from demonstrators is also useful in determining the dynamics of the course.

Another consequence of the increased size of classes has been the necessity for greater co-ordination and preparation, particularly for practicals. A manual is now provided to students in each semester.

Analysis of Assessment Results

Students' performance in the various assessment components of SFP Biology from 1995-2000 were collated, standardised and analysed. Student performance on individual questions and total scores were analysed using Repeated Measures Analysis of Variance (ANOVA, Statsoft, Tulsa) for validity. Performance data from 1995-2000 was compared. SFP students' performance in class marks, theory and practical exams was compared using Repeated Measures ANOVA and regressions. Frequency histograms were also produced for various performance indicators. All statistical analyses were conducted using Statistica (Statsoft, Tulsa).

RESULTS

Analysis of SFP Performance

There was an increase in the number of SFP Biology students since 1995 (Table 3.1). A small percentage of these students fail SFP Biology and this has varied between years (Table 3.1).

Comparison of SFP final Biology marks between 1995-2000 showed a significant difference (ANOVA; $df = 5,655$; $F = 4.14$; $p = 0.001$) although final marks ranged from 58.5 -

62.8 % (Figure 3.2). A post-hoc Scheffe test showed a significant difference between the specific years 1995 and 1999 ($p < 0.05$) showing that there were major differences between these 2 years.

Comparison between years 1995-2000 and June final mark and November Final Biology marks showed a significant difference (RMANOVA; df = 5,653; F = 63.86; p = 0.00). Generally students performed better in June (midyear) than in November (final) (Figure 3.1). June final marks ranged from 58.60 (1998) - 67.8 (1995) while November final marks ranged from 58.47 (1997) - 62.8 (1995).

Comparison of first semester practical, tutorial and test results from 1995-2000 showed that students performed better in practicals which reflects the emphasis at this period of the course (Figure 3.2a). Similarly in the second semester SFP students generally perform better in practicals (Figure 3.2b). There was a significant difference between years 1995-2000 and second semester practical, test and theory marks (RMANOVA; df = 10, 1306; F = 27.26; p = 0.00). This shows that the marks differed between years as well as for the components that made up the marks.

Comparison of June class marks and November class marks between years 1995-2000 showed a significant difference (RMANOVA; df = 5,652; F = 38.00; p = 0.00). Generally June class marks were higher than November class marks (Figure 3.3).

June SFP Biology class marks, theory and practical examinations differed significantly between 1995-2000 (RMANOVA; df = 10,1302; F = 33.02; p = 0.00). June class marks were generally higher than June theory and practical examinations (Figure 3.3). Final SFP Biology theory and practical examinations differed significantly between 1996-2000 (RMANOVA; df = 4,612; F = 17.24; p = 0.00). Final SFP Biology theory and practical examinations marks were lower than November class marks. Comparison of November class marks, theory and practical examinations between 1995-2000 showed a significant difference (RMANOVA; df = 10, 1306; F

= 21.26; $p = 0.00$)(Figure 3.4). A post-hoc Scheffe test showed a significant difference between class marks, theory and practical ($p < 0.05$).

Comparison of final SFP Biology practical examinations between 1996 and 2000 showed they were significantly different (ANOVA; df = 4 ; $F = 15.37$; $p = 0.00$)(Figure 3.4). Students generally improved in practical performance.

When the components of the November theory examination were examined from 1996-2000, there was a significant difference between MCQ, short questions and essay questions (RMANOVA; df = 8, 1222; $F = 69.46$; $p = 0.00$)(Figure 3.5). Students always performed best in MCQ and generally poorly in essay questions. Scheffe tests showed no significant difference between years ($p > 0.05$) but a significant difference between MCQ, and short questions and essay questions ($p < 0.05$). Overall means from 1996-2000 for MCQ, short questions and essay questions were 72.8, 53.4 and 52.2% respectively.

DISCUSSION

Despite the development of SFP students in the Biology component, analysis of SFP Performance in Bioscience 1st year courses showed that SFP students performed poorly in those tasks that required higher cognitive skills (Chapter 2). This is not isolated, as other studies of assessment of student achievement suggest that many students fail to develop effective thinking and problem solving skills (Bransford *et al.* 1986). This questions whether the course as a whole has failed despite its educational philosophy, or whether the teaching and/or assessment have failed in their contribution to the overall aim. This may obscure the need for curriculum change. The assessment forms used in the SFP theory examinations mirror those of the mainstream courses. This may result in modifying students more to respond to the course requirements rather than shaping the curriculum to the students. However, the teaching and practicals used in SFP are more interactive, and the students receive more frequent feedback on assessment tasks than the mainstream courses (pers obs.). Although the philosophies of both the SFP and mainstream courses are said to be similar, further dialogue between all those teaching the courses is required to determine the level of implementation of this in the various courses. At both levels, SFP and mainstream, the theory component needs to be more contextualised to determine if this improves students' performance.

Yet the goals of the constructivism philosophy of SFP Biology course in terms of objectives, teaching, content, and assessment appear to be met. The final mark awarded to an SFP Biology student appears to be a valid indication of their performance at this level considering that the final mark is not a once off assessment but rather a summative of numerous assessment tasks. Despite this, it appears to be a poor indicator of performance in the higher level Bioscience course (Chapter 2). This appears to be a contradiction. A reason maybe that despite SFP students developing their biological conceptual knowledge during the year (Feltham *et al.* 2001), it appears that their cognitive and language skills are poorly developed as they perform poorly in the theory component. Students performed better in MCQ compared to short or essay questions. Student performance questions how much is achievable in a foundation year. It also highlights the need for curriculum changes in teaching, learning and assessment both at the SFP and first year Bioscience levels, an interaction between those teaching both levels of courses, and the determination of how much students are to be prepared for the courses rather than the curriculum to the students. Furthermore, there are numerous factors including socio-economic factors external to the course that affect previously disadvantaged students performance at higher tertiary levels which need to be considered (Downs and Drummond in press).

The results show better performance in the MCQs, and poorer performance in the short answer and essay questions. In addition there is a difference between practical and theoretical marks. These trends perhaps indicate a tendency towards more recall oriented tasks, and greater difficulties with written tasks. This perhaps indicates a combination of problems in language and in poor background knowledge so possibly difficulties in constructing succinct scientific arguments. It would appear that the skills required for more theoretical tasks need ongoing practice and development over a sustained period. This would need to be continued into the mainstream courses if students' were to improve.

SFP assessment

The final mark for SFP Biology is a summation of numerous theory and practical tasks performed by the students although the contribution of the final examinations forms a large proportion. Consequently the final mark should reflect the students' performance and their ability to cope with the tasks. The varied forms of assessment help determine students' competence and their achievement of the outcomes of the course. Although the types of assessment tasks mirror those in first year Bioscience, it appears that their achievement in SFP Biology does not guarantee success in the 1^{st} year course, particularly in those aspects that require higher order cognitive skills (Chapter 2).

As the SFP numbers have increased it appears that there is a greater range in the ability of students with more students at the lower and upper ends. Despite this the final SFP Biology mark has not differed greatly between 1995-2000 although the differences are significant with some years significantly different to others. Comparison between years of marks for each of the other assessment parameters (classmark, practical, theory) respectively showed few trends except that students generally achieved higher marks in June compared to November. This probably reflects the developmental structure of the course with more emphasis on practicals in terms of contact time in the first semester. In addition, the increased workload in the second semsester may have students using rote learning that in turn may produce poorer results.

Biology SFP students generally performed well in practicals. They had difficulties with the theory examinations especially with the short answer and essay questions. This suggests poorly developed higher cognitive and/or language skills. Following feedback from 1st year lecturers, SFP students have poor skills in the following areas: summarising, identifying key concepts, discussion, essay writing and comprehension (pers. comm., pers obs.). In addition their biological language knowledge is poor (Feltham and Downs 2001). Most students have misconceptions about fundamental biological concepts (Feltham and Downs 2001). This suggests that the students have opted for surface level learning and consequently the curriculum does not create meaning for them. It might follow that if students' have poor background and time pressures that they may not have a choice.

Educational Perspectives

The SFP Biology course appears to enhance and empower students as participants in the process of learning. This is reflected in their increased confidence (Barnsley unpubl. data) and ability to tackle most tasks at the SFP level. This empowerment is the primary function of Higher education (Harvey 1997). Furthermore the course attempts to develop a variety of attributes in students, apart from the discipline knowledge, which are important for the transformation of students (Harvey 1997). The assessment procedures appear to encourage deep learning and facilitate the empowerment of the learner (Feltham and Downs 2001). The assessment system appears to rank highly in quality following Harvey's (1997) criteria:

- clear curriculum aims;
- transparent expectations of outcomes understood by staff and students;
- assessment of a range of integrated learning outcomes;

- assessment methods that are valid measures of the intended learning outcomes;
- multiple assessment methods to assess multiple aims;
- useful feedback to students;
- assessment data that informs the process of continuous quality improvement of learning.

There is also frequent interaction between SFP Biology staff with one another and with the other SFP staff that further enhances the understanding of the course dynamics. This has to be harnessed for curriculum development.

The purpose of assessment influences learning, allows staff and students to know if concepts have been learned (Freeman and Lewis 1998). In particular it allows teachers to select, to certificate, to describe, to aid learning and to improve teaching (Freeman and Lewis 1998). Modes of assessment vary from formal and informal, formative and summative, final and continuous, and assessment of product and process (Freeman and Lewis 1998). Assessment criteria are very important but there are often large differences in the degrees to which criteria are made explicit (Freeman and Lewis 1998). Feedback to students is also important (Freeman and Lewis 1998). Both the SFP and mainstream courses need to discuss, examine and make the criteria used in assessment tasks explicit.

Assessment also requires the describing of the learning (Freeman and Lewis 1998). In particular, the learning outcomes and the balance of content need to clearly described and compared. Furthermore, these need to be analysed in terms of their cognitive requirements.

With respect to methods of assessment, they may vary from objective questions, short-answer methods or written long-answer methods (Freeman and Lewis 1998). The multitask nature of writing, the coordination of knowledge, and the processing during composition require interactions between working memory and knowledge stored in long term memory (McCutchen 2000). Written long-answer methods cause problems in assessment, as each demands considerable competence of students, irrespective of the subject being assessed (Freeman and Lewis 1998).

Unless learners have mastered all these skills, long answer methods will fail to reveal what they have and have not learnt from a subject (Freeman and Lewis 1998). Nor can the demands these methods make on students' general writing skills be ignored- unless these are the skills that one wants to assess (Freeman and Lewis 1998). Essay questions vary considerably in nature and in the demands they make on students. Some are very open, others structured. Different types of essay are suitable for assessing different aspects of students learning and different course outcomes (Freeman and Lewis 1998). Long answer methods fail to provide valid assessments when learners do not possess the skills intrinsic to the methods. Therefore, discussion is needed between the teachers of SFP Biology and the first year Bioscience course to address this problem.

The development of higher cognitive skills that enable students to be independent learners and creative problem solving users of their knowledge has always been a very important goal for educators (Chipman and Segal 1985). There is evidence, however, that explicit instruction in these skills is rare and students' mastery of them is frequently inadequate (Chipman and Segal 1985). Regarding thinking skills, there is a fundamental assumption that there are a set of skills, or processes that are common to thinking in general (Adams 1989).

Students high in general ability tend to succeed with instructions that offered little assistance, whereas those of less ability profited from various forms of assistance (Tobias 1989). There is comparable difference between those with low or high relevant prior knowledge (Tobias 1989). Students with constructive motivation (preferences for learning independently, not anxious or defensive) tend to benefit from less structured instruction. Anxious, more defensive students benefit from instruction that is more clearly structured (Tobias 1989).

College level thinking skills to overcome transfer problems require metacognitive skills, real-life examples and emphasis on writing skills (Block 1985). Organisation and awareness are fostered by encouraging students to articulate thoughts, discuss ideas, and apply information (Raaheim 1991). Theories of access should provide a framework for helping students to think and solve problems (Bransford *et al.* 1986). In terms of the SFP Biology and higher level courses, this needs to be analysed to determine the degree that this is required by the various assessment forms and tasks used. Instruction that emphasises memory for fact will seem effective if students are tested on this information (Bransford *et al.* 1986). However, despite a courses' intention to get students out of this mode, their performance in assessment can be expected to be low. Despite efforts by the teachers (Akhurst pers. comm.) in first year Bioscience to implement a course that encourages discussion and application, there has been little improvement in general students' performance (Chapter 2). In particular disadvantaged students perform poorly (Chapter 2). Although multiple methods of assessment are employed, the practical and theory examinations contribute a large proportion to the final mark. Different types of assessment are perhaps required, particularly to reduce tension. In university assessments- generally all the rules for psychological testing are violated (Raaheim 1991). Both the reliability of examination results and their validity as expressions of knowledge or insight into subject matter are highly questionable at times (Raaheim 1991). It questions whether the students would have performed better with a different type of test. It also requires analysis and assessment of the curriculum of the first year courses in Life Sciences following the foundation year. In particular, there needs to be discussion of the consistency of philosophy both within and between courses. " Too often, assessment reflects confusion, mismatching purposes to paradigms or techniques. Confusion in assessment policy typically produces systems that unintentionally limit the benefits of the given approach and that fail to accomplish fully the original assessment purposes. If we understand differences in assessment approaches, we are in a better position to develop coherent assessment systems and to coordinate assessment with teaching and learning" (Mabry 1999, p. 23). Hopefully the performance of students will reflect their ability if the above are addressed.

In summary, the SFP students across the years have shown greater ability in practical compared with theoretical tasks. Within, the theoretical tasks, they had greater difficulties with tasks that required constructing succinct scientific arguments. Students performed better in MCQ rather than short questions or essays. It would appear that the skills required for more theoretical tasks need ongoing practice and development over a sustained period. This would need to be continued into the mainstream courses if students were to improve. Furthermore, the issue of whether students are having a range of negative experiences that affects their persistence in the sciences needs investigation at both the SFP and Bioscience levels.

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Table 3.1. Summary of Biology SFP assessment results from 1995-2000 (mean ± SE).

	1995	1996	1997	1998	1999	2000
n	44	109	109	131	140	128
1st semester						
Practical	66.7 ± .82	66.22 ± .67	71.92 ± 1.24	65.93 ± .79	65.38 ± .65	71.22 ± .89
Tutorial		59.57 ± 1.05	62.65 ± 1.08	54.24 ± 1.09	60.36 ± 1.17	58.26 ± 1.05
Short loan	73.4 ± 1.46	78.71 ± .88	64.38 ± 1.29	52.78 ± 1.22	63.01 ± 1.15	73.79 ± 1.04
Report	71.8 ± 1.02	61.46 ± 1.00	62.22 ± 1.03	58.78 ± 1.24	65.04 ± .98	72.92 ± .77
Test	70.9 ± 1.35	52.41 ± 1.14	59.22 ± .92	57.44 ± 1.06	64.05 ± 1.04	65.25 ± 1.21
Total theory	71.6 ± .89	62.97 ± .81	63.95 ± 1.00	55.49 ± .87	62.88 ± .84	67.20 ± .86
June class mark	68.7 ± .72	64.92 ± .57	68.73 ± .95	61.75 ± .69	64.38 ± .66	69.61 ± .77
June theory exam	66.6 ± 1.29	58.81 ± 1.10	59.39 ± .82	52.13 ± 1.00	69.61 ± .87	65.27 ± 1.32
June prac. Exam	68.1 ± 1.50	62.88 ± .83	66.27 ± 1.06	61.49 ± .86	61.61 ± .99	60.39 ± 1.29
June Final mark	67.8 ± .98	62.23 ± .68	64.80 ± .73	58.60 ± .72	65.22 ± .71	65.68 ± .81
2nd semester						
Practical	66.9 ± 1.12	67.39 ± .72	63.53 ± .63	67.08 ± .79	65.40 ± .83	72.21 ± .72
Test	63.6 ± 1.70	54.47 ± 1.05	53.70 ± 1.16	48.49 ± .86	53.58 ± 1.16	59.85 ± 1.28
Total theory	63.6 ± 1.70	55.52 ± 1.06	55.37 ± 1.15	60.01 ± .97	67.26 ± .89	62.92 ± .81
November class mark	65.6 ± 1.16	62.64 ± .72	60.20 ± .68	64.25 ± .66	66.14 ± .73	68.50 ± .67
November short question		48.87 ± 1.36	50.17 ± 1.64	62.87 ± 1.45	47.43 ± 1.22	57.46 ± 1.36
November MCQ		72.05 ± .99	80.51 ± 1.07	69.37 ± 1.05	69.07 ± .92	64.04 ± 1.09
November essay		51.32 ± 1.54	45.08 ± 1.61	51.62 ± 1.38	63.49 ± 1.24	49.67 ± 1.85
November theory exam	66.5 ± 1.84	58.36 ± 1.02	57.75 ± 1.23	60.69 ± 1.10	58.21 ± .92	57.12 ± 1.29
November prac. Exam	50.3 ± 1.55	52.61 ± .85	53.45 ± .80	57.84 ± .87	62.40 ± .91	55.95 ± 1.41
Final mark	62.8 ± 1.09	58.99 ± .66	58.47 ± .78	62.03 ± .79	62.20 ± .70	61.09 ± 1.00
Failures	0	7	14	10	11	18

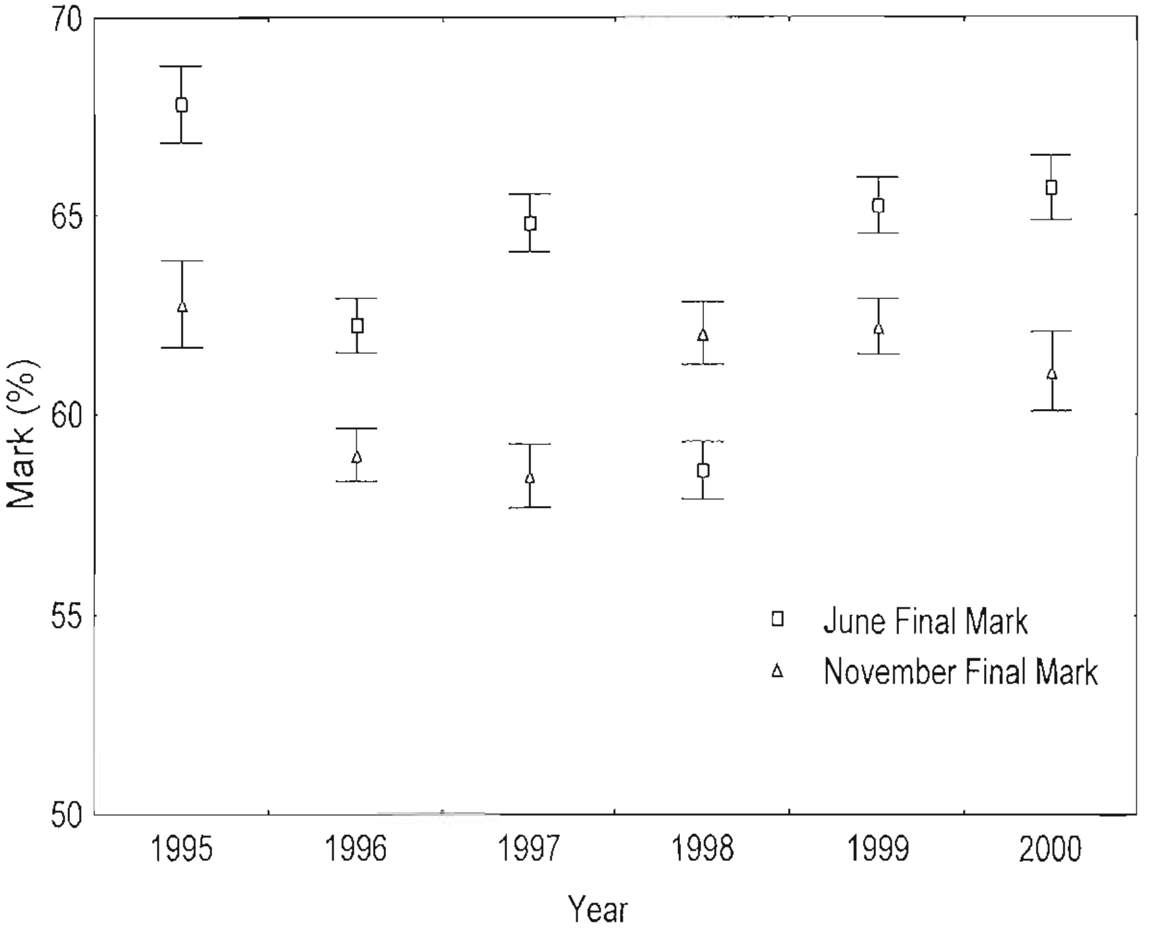
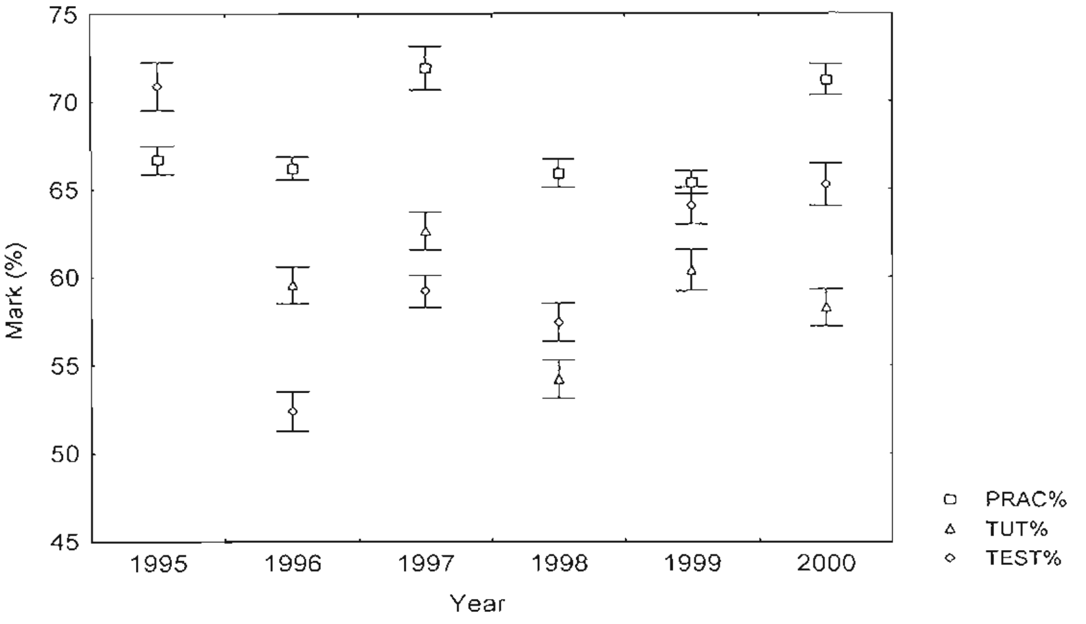


Figure 3.1. Comparison of SFP June and November final marks between 1995-2000.

a.



b.

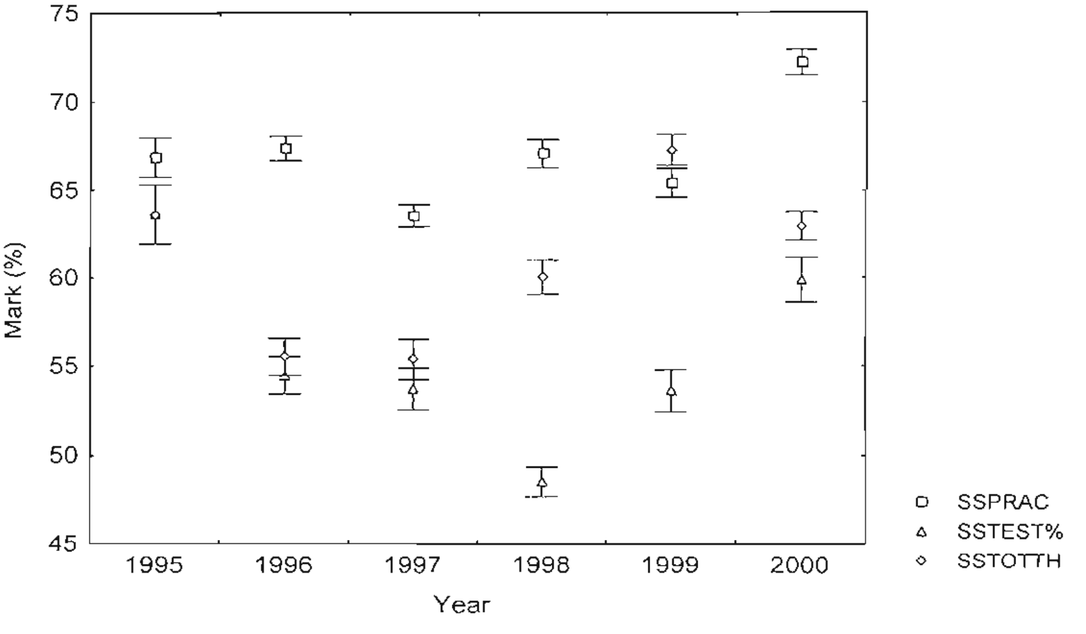
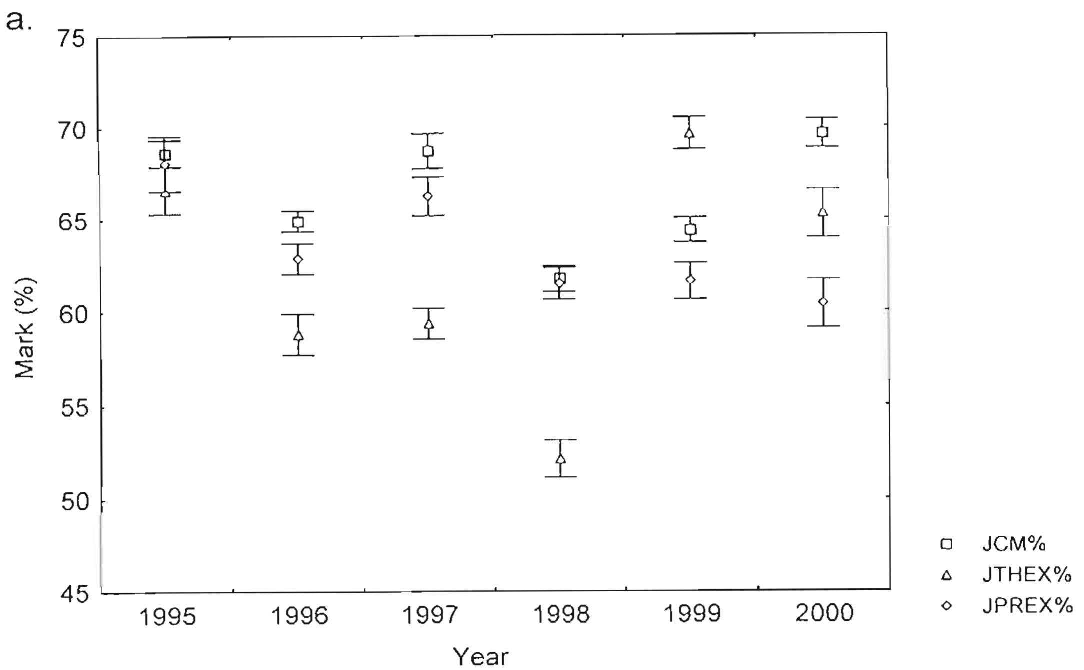


Figure 3.2. Comparison of SFP Biology practical (PRAC), test and total theory (TOTTH) results from 1995-2000 in a. first semester and b. second semester.



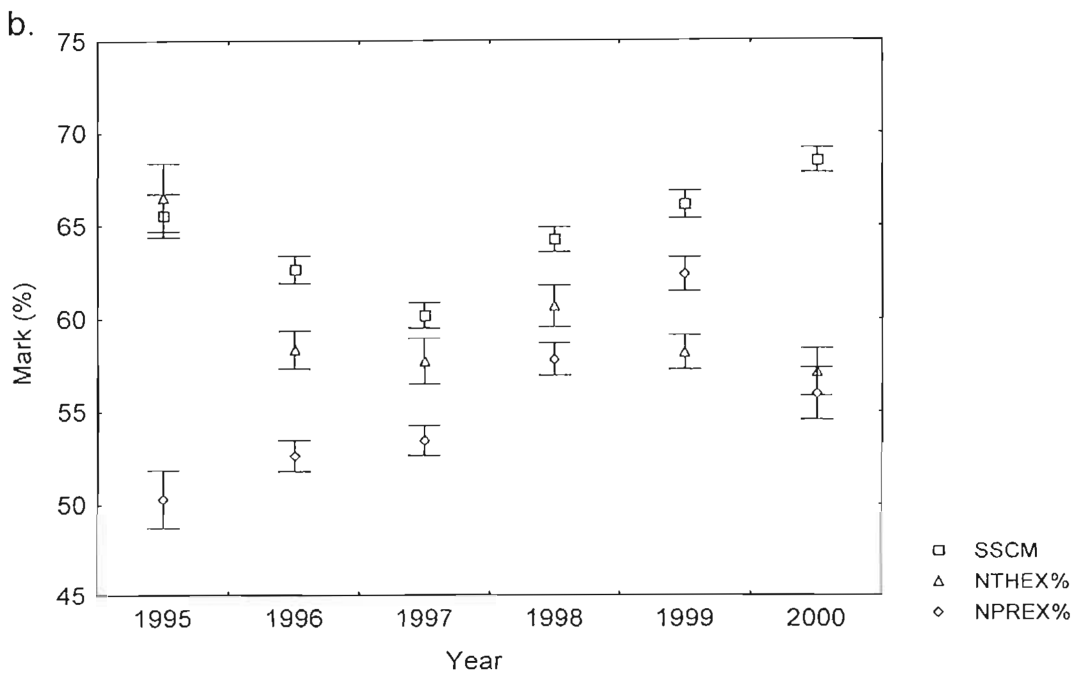


Figure 3.3. SFP Biology class marks (CM), theory (THEX) and practical examinations (PREX) in a. June- first semester and b. November- second semester.

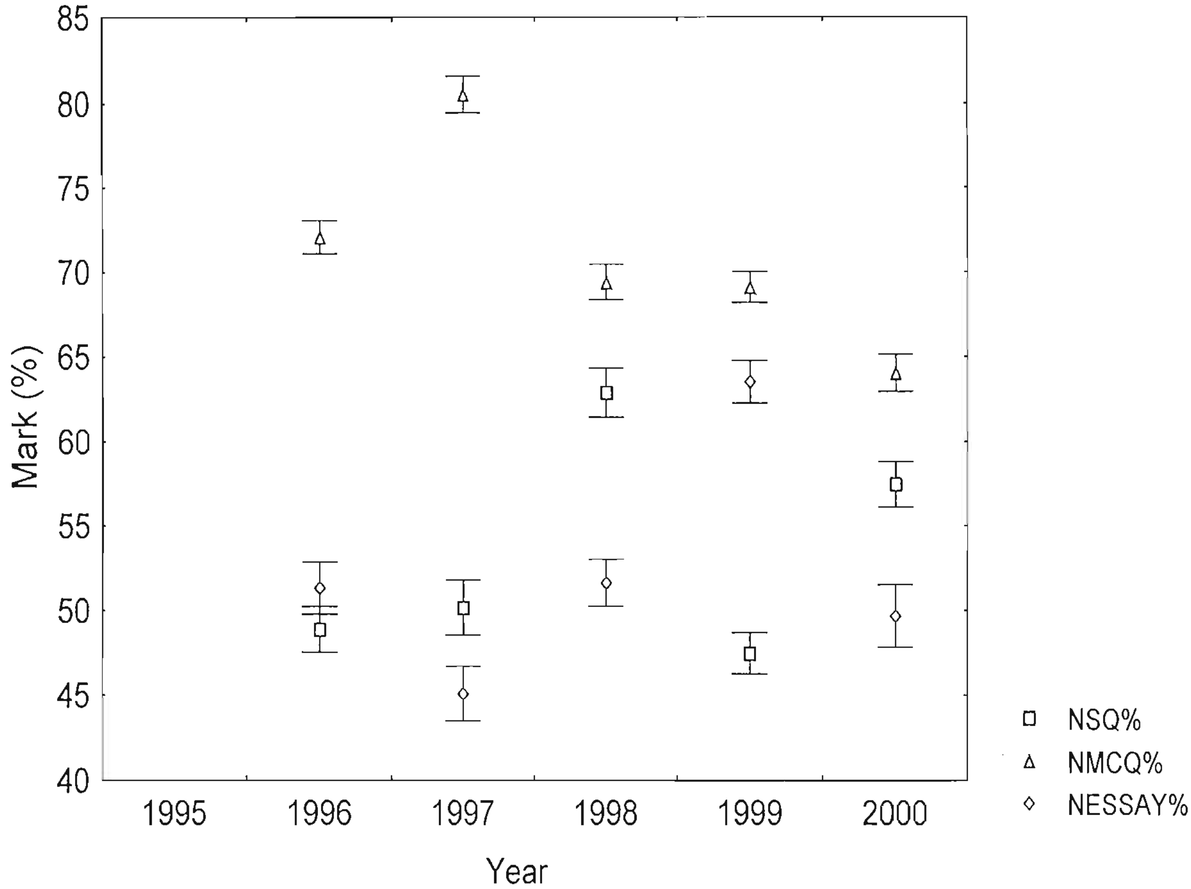
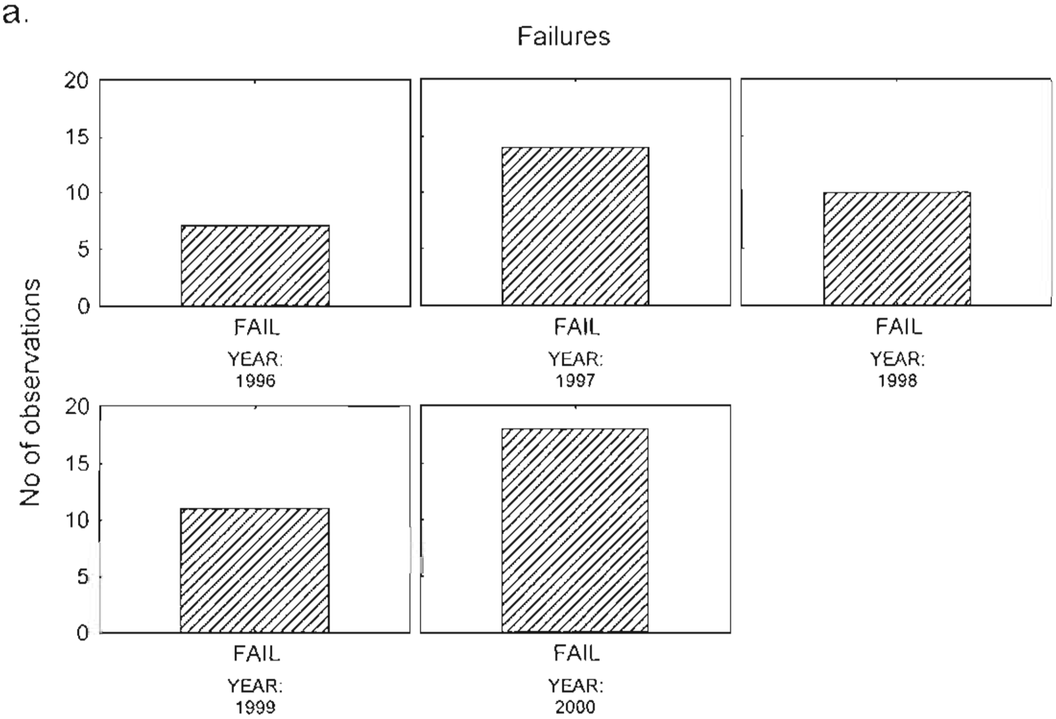


Figure 3.4. Components of the November theory examination from 1996-2000: MCQ, short questions (SQ)and essay questions.

a.



b.

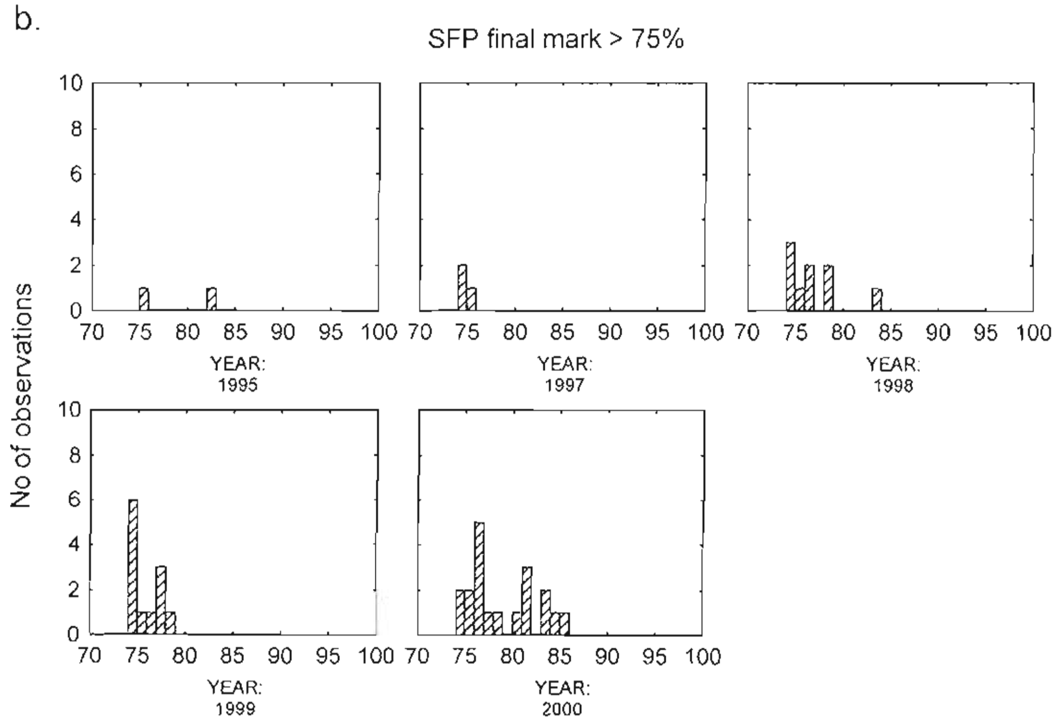


Figure 3.5. Comparison of the ends of the distribution of final SFP marks from 1995-2000 where a. failures (final mark < 50%), and b. distribution of marks and number of students >75%.

CHAPTER 4

CONCLUSION

Few Black students are majoring in the Life Sciences at the University of Natal, Pietermaritzburg (UNP). In the present study, an analysis of performance of a subgroup of Bioscience students, the Science Foundation Programme (SFP) students in their year prior as SFP Biology students was done. These students form the bulk of Black students registering for Bioscience. This was followed by a comparison of student performance in a prescribed first year Life Science course, Bioscience.

In courses at tertiary institutions, changes over time in such areas as curriculum implementation, emphasis, context and style of questions, mark schemes and lecturer's judgement of what is satisfactory are seldom monitored. However, there continues to be discussion of and concern for standards, students' performance and access. Consequently studies such as the present in a situation where teaching staff has remained relatively unchanged should provide some indicators into students' performance and areas for concern.

Monitoring trends in performance in the Bioscience course indicates similar trends across all the identified groups in the study. Most students performed better in practical tasks than in the short-answer and essay questions (Chapter 2). However, those students from previously disadvantaged backgrounds performed the poorest across all tasks (Chapter 2). In tasks contributing to the theory mark, ESL students performed poorly in short questions and essays (Chapter 2). The contribution of the short answer and essay to the final grade, and the development of essay writing ability, requires attention.

The performance of SFP Biology students (Chapter 3), as represented by a final grade, which reflects both the practical and theoretical aspects of the foundation course, was investigated. It appears that students require more development of higher order thinking and language skills to perform better in those tasks that require these (Chapter 3). In the theory examination students performed best in the MCQ component compared with the short questions or essays.

There is debate as to whether poor performance in academic tasks by ESL students is because of language or conceptual difficulties (Inglis 1992). It appears that these two aspects are closely interrelated (Inglis 1992). It appears that students' proficiency in written English is dependent on their understanding of the task and the scientific concepts relevant to that task (Inglis 1992).

In science language is the tool for communicating meanings and solutions (Fathman *et al.* 1992). In the essay writing of ESL students coherence may affect the mark awarded. Coherence is essential if writing is to communicate the intended meaning (Bamberg 1984). Many problems in writing require attention at the level of the whole discourse (Bamberg 1983). Students' prior knowledge affects understanding of text and ability to write coherently (Bamberg 1983). In addition, mastering a skill or body of knowledge requires great amounts of time and effort (Angelo 1993). Furthermore, learning to transfer, to apply previous knowledge and skills to new contexts, requires a great deal of practice (Angelo 1993).

In the initial years of SFP there was emphasis on the development of communication skills with the language course integrated with the other subject courses (Inglis and Grayson 1992). However, in recent years as numbers have increased and staff have changed, the integration has been drastically reduced (pers. obs.).

Emphasis on practical work may improve motivation and memory, but not necessarily scientific understanding (Longden 1994). There is support for the view that people need to use language in order to develop what they think and the way in which they think (Longden 1994). Second language learners usually have "basic interpersonal communication skills" (BICS) which is required in context -embedded and cognitively undemanding situation (Cummins and Swain 1986 in Longden 1994). Their language needed for learning is dependent on their "cognitive academic language proficiency" (CALP) where there is reduced context, and a higher cognitive demand (Cummins and Swain 1986 in Longden 1994). The latter needs to be developed in ESL students. This requires greater interaction and discussion of ideas (Longden 1994).

All thinking and reasoning processes that contribute to critical thinking require practice (Arons 1990). In many forms of assessment it is assumed that students have reasoning, thinking and linguistic processes (Arons 1978). Further research into the levels of cognitive development especially of higher order thinking skills is required at both the SFP Biology and Bioscience levels. This in turn needs to affect ongoing curriculum development that examines the types of assessment used to award a final grade. In particular, the contribution of essay writing needs to be monitored.

Little research has focussed on the deficiency of the quality of testing. "It is useless to render lip service to sophisticated intellectual goals and then test only for end results, vocabulary, "facts" or information". The real goals of a course are determined not by what we say but what we test for" (Arons 1990, p326). Consequently the quality of test questions and writing assignments needs to be examined as part of the course curriculum design, development and teaching of both Bioscience and SFP Biology. A new role for SFP may be the prompting of curriculum change or raising questions.

In the present study only performance of students was investigated. Further research should investigate how students perceive the assessment and whether the course addresses the factors that influence students' perceptions of assessment (Jacob *et al.* 1999). These include failure to make assessment criteria explicit, failure to give clear instructions in the assessment task, inappropriate assessment methods (given the intended learning outcomes), failure to provide students with detailed and meaningful feedback, failure to provide students with formative opportunities to practice the forms of assessment used formatively, and a lack of inter-rater reliability (Jacob *et al.* 1999).

The present study has examined performance of UNP students in both SFP and Bioscience (Chapters 2 and 3). The main factor considered was ethnic group. However, the problem is complex and other factors such as gender, age, motivation and other subject choices might affect their achievements. If the performance of SFP students in Bioscience is to improve, students with higher SFP marks need to be encouraged to enrol for the course particularly if SFP is the main source of Black students that enrol for the course. Consideration of the teaching and structure of the courses need to be considered, and greater interface between them should be encouraged.

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